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1 Executive Summary

As a result of recent and past failures of the Northeast Interceptor Sewer System, the City has commissioned a study to evaluate the capacity, condition, and reliability of the regional Northeast Interceptor (NEI) Sewer System. The purpose of the study is to recommend improvements to the system that will provide adequate future capacity and ensure a high level of reliability. Improved reliability will ultimately reduce failures and provide a system that maintains the public health and confidence.

To meet these objectives, four primary study components were identified:

1. a pipeline condition assessment
2. an operational evaluation
3. a capacity analysis
4. and a criticality assessment

1.1 Background

The NEI as defined for this study consists of two separate pumping systems. Pump Station 35 (COW PS 35 – Bradley Creek Pump Station), located near Bradley Creek delivers flow via a 20-inch force main to gravity sewer just upstream of Pump Station 34 (COW PS 34 – Hewlett’s Creek Pump Station). Pump Station 34 delivers flow to the M’Kean Maffitt Wastewater Treatment Plant (Southside WWTP) via a 24-inch force main. The location of the pump stations and force mains are depicted on Figure TM 4.1 in Technical Memorandum #4 (TM #4) included as Appendix A.

Over the 23-year life of the NEI System, there have been several failures, rehabilitations, replacements, and reroutings of the force mains and gravity sewer. Table TM-4.1 (TM #4) catalogs each failure of the 24-inch force main with the associated rehabilitation, replacement, or rerouting as reported to our team by the City, County, and Town. Table TM-4.2 catalogs each failure of the 20-inch force main and gravity sewer with the associated rehabilitation, replacement, or rerouting as reported to our team by the City, County, and Town. Figure TM-4.3 delineates the general location of each rehabilitation, replacement, or rerouting.

The historical failures fall into two (2) categories: failure due to internal hydrogen sulfide induced corrosion of the pipeline and failure of repair clamps and couplings (mechanical failures). It is evident that internal corrosion has been a recurring problem, beginning as early as six years after the initial construction.

1.2 Approach

A series of kick-off meetings were conducted with City, County, and Town staff and US Filter personnel to further identify issues and concerns related to design, construction, and future operation and maintenance of the existing and proposed facilities. Our project team worked closely with City, County, and Town staff to identify the critical issues for inclusion in the study. To further facilitate input from the NEI Technical Review

Committee (TRC) and ensure expectations were met, regular NEI TRC meetings were scheduled.

1.2.1. Data Collection

The initial task was to collect available data related to the existing system and projected development and growth. Drawings, past studies, pertinent master plans, and information on previous repairs were assembled. Various staff interviews and field reviews were conducted with stakeholder engineering and operations staff at locations throughout the force main alignment and at pump stations. We then conducted a field review of the entire project area to verify the accuracy of the data collected where possible. Locations for potential problems were inspected for inclusion in the study. These areas included air-release valves, easements, areas of past repairs, as well as odor and corrosion control systems.

1.2.2. Deficiency Identification and Repair

Due to the urgent need to identify problematic sections of the existing force mains and quickly make repairs, we recommended implementation of our unique Deficiency Identification and Repair Program (DIRP).

DIRP condensed the timelines of the traditional rehabilitation process, while providing the NEI team full control over project costs. With DIRP, the team began preparing bid documents for urgent force main repairs that will be competitively bid. The bid documents included technical specifications and bid items for all anticipated types of repairs and project conditions that are expected to be encountered for this type of project.

1.2.3. Field Deficiency Investigation (Pipeline Condition Assessment)

A significant concern in the NEI was the extent of hydrogen sulfide corrosion in the ductile iron piping that has occurred over its 23-year installed life. As reported by City operations staff, hydrogen sulfide corrosion very likely reduced the thickness of the pipe wall in certain areas and reduced the pipe's pressure rating below its design pressure, compromising the pipeline's overall structural integrity.

For pipeline thickness assessments, the use of equipment requiring insertion into the pipeline would have required costly temporary bypass pumping, operational and maintenance headaches, and limited timeframes for inspection. For these reasons, the use of non-destructive ultrasonic pipe wall thickness testing was viewed as the best alternative for investigation of the pipeline since it could be performed completely from the exterior of the pipeline with no interruption to system operation.

As field investigations began, the stakeholders were consulted to establish criteria for classification of pipe deficiencies based on measured thickness. A Deficiency Identification and Repair Technical Memorandum (TM #4) was prepared that summarized the background, study methodology, findings, and recommendations for improvements. TM #4 is included in Appendix D.

As part of the field deficiency investigation, a corrosive soils investigation was conducted to identify locations of corrosive soils within the project area. Soil samples were collected along the force main route near the pipe invert at intervals of approximately 500 feet. The objective was to identify areas where there is the potential for external corrosion due to a corrosive environment. A corrosive soils investigation report was submitted by the Ductile Iron Pipe Research Association (DIPRA) and is included in Appendix F.

1.2.4. Capacity Analysis

A capacity analysis was performed concurrently with the field deficiency investigation to evaluate the system's ability to meet both current and long-term wastewater needs for the system service area.

To resolve the need for future wastewater capacity, we developed flow estimates based on population and land use projections. The flow projections were converted to peak wastewater flows by reviewing historical metered wastewater flows in the service area. A Capacity Analysis Technical Memorandum (TM #1) was prepared that summarized the background, study methodology, findings, alternatives, and recommendations for improvements. TM #1 is included in Appendix A.

1.2.5. Operational Evaluation

An operational evaluation was performed to assess the operational and maintenance procedures for the NEI System. Odor and corrosion control, pump station monitoring and control, and easement management were identified by the NEI stakeholders as critical operational components to be evaluated. Odor and corrosion control were addressed through an evaluation of the following:

1. current Odor Corrosion Control Program (OCCP)
2. areas with hydraulically induced corrosion
3. force main discharge options at City of Wilmington Pump Station 35 (Bradley Creek)
4. air release valve operation and maintenance program

Monitoring and control issues were assessed through an evaluation of daily pump station data collection and SCADA pump station monitoring and control. Easement management was addressed by a review of current practices and development of an Easement Management Plan.

Based on our evaluation of the operational and maintenance procedures, we prepared an Operational Technical Memorandum (TM #2) summarizing the background, study methodology, findings, and recommendations for implementation of improvements. TM #2 is included in Appendix B.

Additionally, a surge analysis was performed through hydraulic modeling to evaluate system performance during a surge (or high pressure) event. Surge modeling was developed to complete these specific tasks:

1. evaluate the potential surge pressures to aid in evaluating the adequacy of the deteriorated pipe
2. evaluate the adequacy/performance of the existing surge protection equipment such as air release valves, combination air/vacuum valves, or surge relief valves
3. identify modifications that will minimize surge pressures and improve the operation and reliability of the system

Our Surge Analysis Technical Memorandum (TM #3) summarizes the background, analysis methodology, findings, and recommendations for improvements TM #3 is included in Appendix C.

1.2.6. Criticality Assessment

The team evaluated the criticality of key system components. The assessment began by conducting a workshop with the NEI team to identify key system assets, define criticality goals and acceptable risk parameters, and assign criticality ratings. Where critical system components fell short of the benchmark risk parameters, we evaluated options for redundancy or alternate methods to meet the goals. A Criticality Assessment Technical Memorandum (TM #5) was prepared that summarized the background, study methodology, findings, and recommendations for improvements. TM #5 is included in Appendix E.

1.2.7. Reliability Improvement Alternatives

As the condition assessment, capacity analysis, operational evaluation, and criticality assessment were in progress, we began to develop alternatives to address issues identified in each of those components. Once those portions were substantially complete, we met with the NEI team to review the information obtained and formulate alternatives to address the various components. We further evaluated these alternatives and developed recommendations that provided improved reliability.

1.2.8. Preliminary Engineering Report

Our Preliminary Engineering Report (PER) summarizes our study methodology, presents our findings, defines the alternatives, and offers our conclusions and recommendations for improved reliability. A draft version of the PER was submitted to all stakeholders for review and comment prior to issuing the final document.

1.3 Recommendations

We recommend implementation of the Capital Improvements Plan and operational modifications which are detailed in the Technical Memorandums and summarized in the Preliminary Engineering Report. To implement these recommendations, we project capital budget of \$26.3 to \$33.9 million over the next four years, depending on whether Major Basin II is included or excluded in the NEI service area. The following is a summary task list of the major steps for implementation of the recommended improvements. Items 1 through 5 should commence as soon as possible and completed simultaneously. The remaining items should be completed in sequential order:

1. Proceed with bid and construction of the recommended Deficiency Identification and Repair Program improvements.
2. Perform the bench scale odor and corrosion control evaluation of the selected chemicals.
3. Implement the recommendations of the Operational Evaluation and Criticality Assessment.
4. Proceed with design of the NEI expansion by initiating the routing analysis, survey, preliminary design, and environmental assessment of the proposed parallel force main from Pump Station 35 to the Southside Wastewater Treatment Plant.
5. Resolve the future direction of wastewater flow from Major Basin II to determine if this flow will be tributary to the NEI and accounted for in the design.
6. Proceed with design of the Pump Station 35 expansion and the re-pump station (if Alternative No. 4 is selected), and final design of the force main.
7. Construct the NEI expansion.
8. Proceed with design of the future force main rehabilitation. This should be scheduled so that design is completed as the NEI expansion is completed so that construction can proceed as soon as possible.
9. Construct the NEI rehabilitation.

2 Introduction

On September 20, 2005, the Wilmington City Council passed a resolution expressing concern over recent sewage spills involving the City's wastewater system. The resolution further expressed intent to direct a full examination of the system and develop a plan of implementation to upgrade the system and assure that the City's citizens "continue to enjoy the quality of life they expect." The resolution directed the City Manager to expeditiously engage the services of a reputable engineering firm to evaluate the overall condition of the various elements of the wastewater system, and to identify implementation strategies to upgrade the system in a manner that reduces failures.

This resolution was instigated by two (2) 2005 sewer spills resulting from failures of the Northeast Interceptor (NEI) System. The first occurred July 1 when a repair band broke and approximately 3 million gallons spilled into Hewlett's Creek. The second occurred September 15 when a portion of the pipeline failed due to internal corrosion and approximately 750,000 gallons spilled into storm sewer that is tributary to Hewlett's Creek. Spills of this type had plagued the system's past. These most recent spills were an indication that the past problems were resurfacing and further investigation was necessary to head off future spills.

On October 10, 2005, the City advertised a Request for Qualifications (RFQ) for the Northeast Interceptor Improvements Project as the first step to implement the evaluation and assessment of the City's wastewater system. The RFQ tasked the selected consultant with evaluating the capacity, condition, and reliability of the regional Northeast Interceptor Sewer System to recommend improvements to the system that will provide adequate future capacity and ensure a high level of reliability.

2.1 Purpose

The purpose of the study phase of this project is to evaluate the existing system and propose recommendations that will provide the high level of reliability desired for the Northeast Interceptor System. This reliability will ultimately reduce failures and provide a system that maintains the public health and confidence.

More specifically, the purpose of this study is to address the critical issues of capacity, condition and reliability through evaluating the following:

1. the current condition and reliability of the existing force main
2. current and future capacity requirements
3. the ability to control the effects of component failures (event management) through operational flexibility, such as planned and potential flow diversions and redundancy, thus minimizing risk to the environment
4. odor and corrosion control requirements and parity
5. system monitoring requirements
6. instrumentation controls and SCADA requirements
7. regulatory compliance

8. operation and maintenance procedures to provide a greater service life for the improved system
9. easement management practices
10. improvements to facilitate system maintenance

In addition, the study should inform the project stakeholders, elected officials, and general public so they understand the recommendations as well as the safeguards that have been put into place to prevent future spills and allow them to enjoy the quality of life they expect.

2.2 Report Format

To meet the study objectives, four primary evaluations were identified:

1. a pipeline condition assessment
2. an operational evaluation
3. a capacity analysis
4. and a criticality assessment

Due to the urgency of this project, these evaluations were performed simultaneously. Five technical memorandums were generated that provide a detailed description of each evaluation including conclusions and recommendations. The memorandums are as follows:

Technical Memorandum #1 – Capacity Analysis (Appendix A)

Technical Memorandum #2 – Operational Evaluation (Appendix B)

Technical Memorandum #3 – Surge Analysis (Appendix C)

Technical Memorandum #4 – DIRP Condition Assessment (Appendix D)

Technical Memorandum #5 – Criticality Assessment (Appendix E)

The Preliminary Engineering Report (PER) integrates the recommendations of the technical memorandums and provides direction for implementing these recommendation to improve the reliability of the NEI System.

3 Existing System

The NEI was designed by Henry Von Oesen and Associates between 1977 to 1981. Originally, the NEI System consisted of two (2) segments. Segment 1 conveys wastewater from Pump Station 1 on Wrightsville Beach to COW PS 35. Segment 2 conveys wastewater to the Southside WWTP as described above.

Segment 2 of the NEI was constructed for New Hanover County by T.A. Loving Co. (pipeline) and Hall Contracting (pump stations), with start-up in September 1983. Immediately after construction was completed, one half ownership of NEI Segment 2 was turned over to the City of Wilmington who was responsible for operation and maintenance per interlocal agreements between the City, New Hanover County, and the Town of Wrightsville Beach. It has been operated and maintained by the City since that time. A Technical Review Committee (TRC) was established at the outset of operation in the Northeast Interceptor Operation and Maintenance Agreement to “concurrently represent the interests of the City, County and Town in the determination of technical standards for collection systems to be permitted connection to the Interceptor, and the types of materials and methods of construction permitted for the physical connection and metering.” The City of Wilmington, New Hanover County, and the Town of Wrightsville Beach each have a representative on the committee.

Segment 1 was designed and constructed as part of the NEI system for the Town of Wrightsville Beach. In accordance with the initial interlocal agreement, The Town of Wrightsville Beach would operate and maintain Segment 1 but would convey ownership to the City of Wilmington, who would lease the system back to the Town. The system was later purchased from the City by the Town. The location of the pump station and force main that make-up Segment 1 are depicted on Figure TM 4.2. Since that system is solely owned and operated by the Town of Wrightsville Beach, it is not part of this study.

3.1 Description

Pump Stations 34 and 35 are the largest and third largest pump stations in the City of Wilmington System. The force lengths are approximately 32,500 LF (24-inch) and 16,500 LF (20-inch), respectively. As of the 2001 Wastewater Master Plan, the combined force main length comprises approximately half of the City’s total length of force main.

3.1.1. COW Pump Station 35 System

COW PS 35 is situated adjacent to Bradley Creek on Oleander Drive. The station consists of a wet well / dry well below ground structure with a masonry superstructure that houses controls and miscellaneous mechanical equipment. The wet well side of the below grade structure provides detention and attenuation of the sewage flows which come into the station.

The dry well side of the below grade structure is where the pumps and related piping and seal water systems are located. Currently there are four pumps within the station, Pump No.1 through Pump No.4. Pumps No.1 and 2 have a rated capacity of 2,500 gallons per minute (gpm), Pump No.3 has a capacity of 4,300 gpm, and Pump No. 4 has a capacity of

4,100 gpm. The sequence of operation is arranged such that Pumps No. 1 and 2 operate alternately at low flows. Once the influent flow exceeds the capacity of Pumps No. 1 and 2 they are shut down and Pump No. 3 is started. If the capacity of Pump No. 3 is surpassed it is shut down and Pump No. 4 is started. Interlocks exist which only allow Pumps No. 1 and 2 to run in parallel; Pumps No. 3 and 4 can only be operated independently. All pumps were designed to operate at variable speeds to match influent flow rates; however, for reliability pump #4 has been temporarily switched to a newer soft-start, constant speed drive.

The superstructure of the pump station is sectioned into several areas. These areas include an operations room, abandoned chemical feed room (now used to house the pump control panel and the temporary soft-starter for Pump No. 4), abandoned generator porch, and air blower room. These areas provide locations for housing critical mechanical and electrical equipment above the 100-year flood plain elevation and to allow ease of access and maintenance.

COW PS 35 collects sewage from the New Hanover County junction box located outside the fence of the pump station. A 24-inch gravity main connects the junction box to the COW PS 35 screening chamber. The County junction box combines flows from a 16-inch New Hanover County force main (Westwood Pump Station #77), a 10-inch New Hanover County force main (Wrightsville Sound Pump Station #57), a 24-inch gravity sewer (from Windemere/Seagate), and an 8-inch New Hanover County gravity sewer.

Flows from the Wrightsville Beach 14-inch force main are transferred to COW PS 35 via a gravity sewer connection between the County junction box and the pump station wetwell.

COW PS 35 discharges through a 20-inch force main that crosses Oleander Drive (US Highway 76) to the east side and extends to the intersection of Greenville Loop Road within the NCDOT right-of-way. From the intersection of Oleander and Greenville Loop, the force main extends along the southeast of Greenville Loop within the City of Wilmington right-of-way to the intersection with the entrance to Oakmont Subdivision (Tidal Oaks Drive). This 20-inch force main collects sewage from six different New Hanover County force mains and one City of Wilmington force main along Greenville Loop Road. At the intersection with Tidal Oaks, the force main discharges to a 20-inch gravity sewer.

From the intersection of Tidal Oaks and Greenville Loop, the gravity sewer extends approximately 450 LF along a cross-country route to COW PS 34.

3.1.2. COW Pump Station 34 System

COW PS 34 is located near Hewlett's Creek on Pine Grove Road. The station consists of a wet well / dry well below ground structure with a masonry superstructure that houses controls and miscellaneous mechanical equipment. The wet well side of the below grade structure provides detention and attenuation of the sewage flows which come into the

station. The station is equipped with a parshall flume on the influent flow to the wetwell; however, during high flow periods the flume becomes submerged.

The dry well side of the below grade structure is where the pumps and related piping and seal water systems are located. Currently there are four pumps within the station, Pump No.1 through Pump No.4. Pumps No.1 and 2 have a capacity of 3,500 gpm, Pump No. 3 has a capacity of 6,000 gpm, and Pump No. 4 has a capacity of 6,600 gpm. The sequence of operation is arranged such that Pumps No. 1 and 2 operate alternately at low flows. Once the influent flow exceeds the capacity of Pumps No.1 and 2 they are shut down and Pump No. 3 is started. If the capacity of Pump No. 3 is surpassed it is shut down and Pump No. 4 is started. Interlocks exist which only allow Pumps No. 1 and 2 to run in parallel; Pumps No. 3 and 4 can only be operated independently. All pumps were designed to operate at variable speeds to match influent flow rates.

The superstructure of the pump station is sectioned into several areas. These areas include an operations room, abandoned chemical feed room (now used to house the pump control panel), abandoned generator porch, and air blower room. These areas provide locations for housing critical mechanical and electrical equipment above the 100-year flood plain elevation and to allow ease of access and maintenance.

COW PS 34 collects sewage from a junction manhole located outside the fence of the pump station along Pine Grove Drive. A 24-inch gravity main connects the junction box to the COW PS 34 screening chamber. The junction manhole receives flow from the COW PS 35, an 18-inch City gravity sewer and a 10-inch County force main.

COW PS 34 discharges through a 24-inch force main that crosses Pine Grove Drive and then roughly parallel to Hewlett's Creek in a 50 foot public utility easement. This easement contains a gravity sanitary sewer as well. The force main extends in this easement to the end of Cascade Drive. It then continues within the City right-of-way of Cascade Drive to cross under South College Road (NC 132) and then cross the Long Leaf Mall parking lot at the intersection of South College and Shipyard Boulevard (SR 1101). The force main then extends along the south side of Shipyard Boulevard, within the NCDOT right-of-way to the intersection with Stonewall Jackson Drive, where it turns south and continues along Stonewall Jackson Drive within the City right-of-way. At the end of Stonewall Jackson, the force main turns west and extends along the south side of Semmes Drive within the City right-of-way. Near the intersection of Semmes Drive and Pettigrew Drive, the force main turns south down a 30 foot wide easement adjacent to Independence Boulevard and continues toward the intersection of 17th Street and Independence Boulevard, where it enters the City right-of-way along Independence Boulevard. The force main continues along Independence Boulevard within the City right-of-way until it leaves the right-of-way just prior to the shopping center at the intersection of Carolina Beach Road and Independence Boulevard. There it follows a 30 foot easement approximately 57 feet off the right-of-way line of Independence Boulevard in front of the adjoining shopping center parking lot. The force main then crosses Carolina Beach Road (US 421) and follows a 30 foot easement for a short distance before re-entering the City right-of-way along Independence Boulevard. The force main

continues within the right-of-way of Independence Boulevard before it crosses River Road and extends along the west side of the City right-of-way along River Road to the Southside Wastewater Treatment Plant.

3.2 History

Over the 23-year life of the NEI System, there have been several failures, rehabilitations, replacements, and reroutings of the force mains and gravity sewer. Table TM-4.1 catalogs each failure of the 24-inch force main with the associated rehabilitation, replacement, or rerouting as reported to our team by the City, County, and Town. Table TM-4.2 catalogs each failure of the 20-inch force main and gravity sewer with the associated rehabilitation, replacement, or rerouting as reported to our team by the City, County, and Town. Figure TM-4.3 delineates the general location of each rehabilitation, replacement, or rerouting.

The historical failures fall into two (2) categories: failure due to internal corrosion of the pipeline resulting from the presence of hydrogen sulfide and failure of repair clamps and couplings (mechanical failures). It is evident that internal corrosion resulting from the presence of hydrogen sulfide has been a recurring problem, beginning as early as six years after the initial construction. During 1989 and 1990, this early corrosion resulted in several failures along Independence Boulevard which led to relining, replacement, or relocation of approximately 3,000 linear feet of the 24-inch force main. Additional failures occurred in the same general vicinity approximately five years later (1994-1995), when approximately 600 LF had to be lined due to internal corrosion resulting from the presence of hydrogen sulfide. Figure TM-4.4 illustrates the location of this early work adjacent to Independence Boulevard.

Failures of the 20-inch force main and gravity sewer did not begin until 1992 when manhole “A” (junction manhole at COW PS 34) was replaced due to substantial deterioration of the manhole. On February 16, 1993 according to the City, the cone on manhole A literally “blew-off”, resulting in a sanitary sewer overflow (SSO). Pipeline corrosion problems resulting from the presence of hydrogen sulfide first appeared in the 20-inch force main in 1992 when approximately 738 feet in the transitional flow area just prior to the discharge to the gravity sewer had to be replaced due to significant deterioration.

There were no additional noted failures of the NEI System until 2004 when the 24-inch force main along Shipyard Boulevard near the intersection with Pine Valley Road failed due to internal corrosion resulting from the presence of hydrogen sulfide. On July 1, 2005, another failure occurred at COW PS 34 when a stainless steel repair band used to connect a pig launching station to the pipeline failed, resulting in a spill of approximately 3 million gallons of sewage into Hewlett’s Creek. On September 15 of the same year, another failure occurred at the same location as the 2004 failure along Shipyard Boulevard. This was attributed to internal corrosion and resulted in a spill of approximately 750,000 gallons of sewage into storm sewer that is tributary to Hewlett’s Creek. Figure TM-4.5 illustrates the location of these failures along Shipyard Boulevard.

These recent spills were an indication that the past problems were resurfacing and that further investigation was necessary to head off future spills. As a result, on September 20, 2005 the Wilmington City Council passed a resolution expressing concern over recent sewage spills involving the City's wastewater system. Kimley-Horn was subsequently selected to evaluate the capacity, condition, and reliability of the Northeast Interceptor Sewer System in order to recommend improvements to the system that will provide adequate future capacity and ensure a high level of system reliability.

As the study got underway, the failures continued into 2006. On February 15, deterioration of carbon steel bolts on a stainless steel repair clamp on the 24-inch force main at the end of Warlick Drive, failed resulting in an SSO.

4 Capacity Analysis

A thorough understanding of current and future flow projections and existing system capacities are needed to make the best decision on when and where to rehabilitate or expand the NEI system. The City of Wilmington and New Hanover County *Wastewater Master Plan* dated July 2001 and the City of Wilmington and New Hanover County *Wastewater Master Plan Update* dated February 2005 prepared by McKim and Creed, PA (Master Plans) focused on large-scale, system-wide planning. Our capacity analysis was a more detailed study of the current flow estimates and future flow projections.

The NEI is unique because there are customers who live in the City of Wilmington (COW) and the Town of Wrightsville Beach (TWB), but are sewer customers of New Hanover County (NHC). In addition the COW, NHC, and TWB are service providers to other customers within their jurisdictions. For the purpose of this analysis, the customer base is discussed in terms of its service provider, not by incorporated area. However, whenever historical statistics (i.e. Census data) are applied to the customer bases, the statistics appropriate to the jurisdictional location of the customer were used to provide the most accurate results.

4.1 Methodology

The Master Plan documented the 81 sewer sub-basins that flow through the NEI. For consistency, this analysis utilized the same sub-basins, but aggregated them into 5 logical major basins systems to evaluate potential flow diversion alternatives.

Future flows were projected by adding projected new flows from undeveloped and underdeveloped areas to the estimated 2005 flow baseline. By comparison to the method used in the Master Plan, this differential-type analysis typically provides a more accurate projection of total future flows.

4.2 Current Flow Estimates

The NEI serves all 5 major basins with the exception of the COW 8 basin (generally bounded by Oleander Drive, College Road, Shipyard Boulevard, and Independence Boulevard). Since Master Plans discuss diverting basin COW 8 to the NEI before 2020, this drainage area was included in the build-out flow projections.

Within each of the 5 major basins, a variety of flow estimating techniques were used to develop unit flow factors:

- Since the TWB monitors and records daily flow from its two pump stations that feed into the NEI, and both pump stations flow into the same Major Basin, actual 2005 meter data was used as the flow for the served population.
- NHC provided GIS shapefiles showing the location of all water meters in the NEI collection system. The data was segregated into residential and non-

residential categories based on zoning information and aerial photography by major basin.

- The COW also provided meter data that was correlated to GIS structure layers and aerial photography to segregate the data into residential and non-residential categories.

In addition, flow data was collected from the COW flow meter located on the outlet of the NEI force main at the Southside WWTP. The City provided five years of monthly average flow data and 2 years of average daily flow and peak instantaneous flow data. The data shows the following:

- Average daily flow in the NEI has increased from 4.13 MGD to 4.48 MGD from 2000 to 2005 (1.64% per year on average).
- Historical wet-weather peak flow to average flow ratio ranges from about 2.3 to 2.8.

4.3 Current System Capacity

The design maximum capacity of COW PS 35 is 4,300 gpm (6.1 MGD) with a firm capacity of 4,100 gpm (5.9 MGD). The velocity in the 20-inch force main from COW PS 35 at firm capacity is 4.2 fps. The design maximum capacity of COW PS 34 is 6,600 gpm (9.4 MGD) with a firm capacity of 6,000 gpm (8.6 MGD). The velocity in the 24-inch force main from COW PS 34 at firm capacity is 4.3 fps.

Applying peaking factors to the COW PS 34 and COW PS 35 firm capacities yield the following pump station design capacities based on average daily flows:

Pump Station	Firm Peak Capacity (MGD)	Peaking Factor	Firm Average Daily Flow Capacity (MGD)
COW PS 35	5.9	2.8	2.1
COW PS 34	8.6	2.6	3.3

Table 4.1 – COW PS 34 and COW PS 35 Capacities

4.4 Projected Build-out Flows

Projected build-out flows were developed by taking the 2005 recorded flows as a baseline and adding projected flows from future basin growth based on projected land use. Undeveloped land and underdeveloped lands were tabulated based on GIS and aerial photography information. Since the GIS and aerial photography information was not 2005 data, it was adjusted with US Census growth factors to estimate the available lands on a 2005 basis. Land uses were determined based on current COW, NHC, and TWB

zoning designations. Where zoning allows multiple land uses, an effort was made to project flows based on probable development, surrounding structures, and location.

Build-out is a theoretical period when all lands have been built upon and development stops. The reality is that build-out may never occur if factors such as a strong economy and recreational attractions are present. When an area comes close to build-out, re-development takes over and development continues, but generally at a slower pace. To account for this phenomenon, we added an over-build allowance to the theoretical build-out in the flow projections developed. The over-build allowance is 5% of the total basin flow, except for the TWB flows, which include a 10% allowance. A higher allowance is used for the TWB because of trends to convert single-family dwellings to multi-family units and due to the higher recreational attractions of the islands.

Build-out flows for the undeveloped and underdeveloped lands were projected using the NEI basin specific unit flow factors. The table below tabulates current estimated average daily flow, additional average daily flow to build-out, and total build-out average daily flow projections by basin:

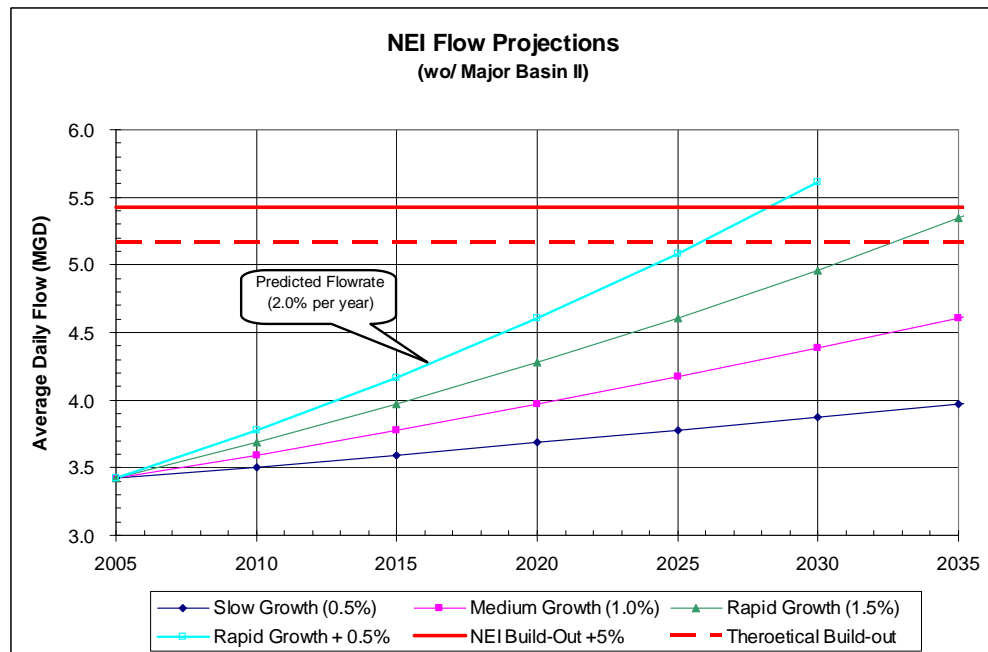
Basin	2005 Flow Estimate (MGD)	Add'l Flow to Build-out (MGD)	Total Build-out Flow (MGD)
Major Basin II	0.39	0.99	1.38
Major Basin III	1.96	0.95	2.91
Major Basin IV	0.54	0.11	0.65
Major Basin V	0.98	0.89	1.87

Table 4.2 – Projected Basin Average Daily Flows at Build-out

4.5 Projected Growth of Flows: Current to Build-Out

A flow growth factor of 2.0% per year was selected for the NEI basin to evaluate the time to build-out for the NEI service area. Based on this growth rate, the graph below shows that theoretical build-out of Major Basins III, IV, and V is expected to occur in about 2026 and build-out, including the 5% over-build allowance, is expected to occur in about 2029. The growth rate may slow slightly as build-out approaches and development becomes more challenging, but we have neglected this slow-down to represent more conservative estimates.

If Major Basin II is added to the NEI flow projections, the 2005 average daily flows increase to 3.9 MGD. The build-out flows increase to 6.5 MGD at theoretical build-out and 6.8 MGD with the 5% over-build allowance.



4.6 Alternatives to Address Future Capacity

Comparing the NEI flow projections to the NEI system capacity of 3.3 MGD (average daily flow) shows that the NEI flows exceeded the NEI conveyance system capacity in 2005. TM #1 details the 24 alternatives (6 base alternatives plus 3 options under each alternative) for dealing with the projected NEI flows.

The Master Plans are based on the re-direction of flows from basins referred to herein as Major Basins I and II. Discussions on this topic have uncovered a disagreement among the NEI partners over whether Major Basin II is intended to be re-directed to the Northside WWTP or to remain as a long-term contributor to the NEI and be treated at the Southside WWTP.

Details of the alternatives reviewed and how they were pared down to two viable alternatives are included in the technical memo (Appendix A). There were two viable alternatives (Alternatives 3 and 4). The discussion below outlines the capacity improvements necessary to implement them.

4.6.1 Divert COW PS 35 Away From COW PS 34 for Major Basins III, IV, V (Alternate 3)

This alternative includes expanding COW PS 35 and redirecting most of the flow so that it would no longer pass through the COW PS 34 (Figure TM 1.4). Under this scenario, the following major components of the NEI would need to be expanded:

- COW PS 35 – Expansion from 5.9 MGD to 8.1 MGD firm capacity.
- COW PS 35 Force Main – Installation of approximately 49,000 LF of parallel 24-inch force main.
- COW PS 34 – No capacity expansion required.
- COW PS 34 Force Main – No capacity expansion required.

Since the operating conditions would change significantly, COW PS 35 mechanical components related to pumping will need to be redesigned.

This alternative will improve the flow diversion capabilities within the force mains downstream of COW PS 35 and COW PS 34 since the pipe line would include several crossover connections between the parallel force mains.

4.6.2 Divert COW PS 35 Away From COW PS 34 for Major Basins II, III, IV, V (Alternate 4)

If the flows from Major Basin II are not diverted away from the NEI, the upsizing would include the following major components (Figure TM 1.5):

- COW PS 35 – Expansion from 5.9 MGD to 11.2 MGD firm capacity with expanded wetwell storage. Due to the constrained COW PS 35 site, the new wetwell capacity is shown to occur at a new pump station off-site.
- COW PS 35 Force Main – Installation of approximately 49,000 LF of parallel 30-inch force main.
- COW PS 34 – No capacity expansion required.
- COW PS 34 Force Main – No capacity expansion required.

Since the operating conditions would change significantly, COW PS 35 mechanical components related to pumping will need to be redesigned for the new duty conditions.

This alternative will improve the flow diversion capabilities within the force mains downstream of COW PS 35 and COW PS 34 since the pipe line would include several crossover connections between the parallel force mains.

4.7 Recommendations

The alternatives and options discussed above should be evaluated with the NEI partners' overall goals and objectives and coupled with the results of the field pipeline testing, reliability assessment, and operational analysis to determine which alternatives are feasible. The two feasible alternatives should be evaluated on a cost and goals basis to determine the best one for implementation. Although implementation of Alternative 4 will be more costly to the NEI, it may be less costly for NHC considering its overall

collection system improvement costs. NHC is performing a capacity analysis on portions of its collection system to determine the impacts of diverting all or a portion of Major Basin II away from the NEI.

5 Operational Evaluation

Operational procedures are integral to providing capacity for future demands, operational flexibility, and a high level of reliability, by providing a system that operates efficiently, reliably, and at maximum design conditions. Study recommendations to improve the capacity, condition, and reliability of the system, must incorporate operational conditions and procedures. Technical Memorandum #2 provides operational recommendations to be considered and incorporated in the overall project recommendations to meet these objectives.

The Operational Evaluation consists of an evaluation of the following components:

1. the current Odor Corrosion Control Program (OCCP)
2. areas with hydraulically induced corrosion
3. air release valve operation and maintenance program
4. system performance during a surge (or high pressure) event
5. daily pump station data collection and trending
6. SCADA pump station monitoring and control
7. easement maintenance and management

5.1 Odor and Corrosion Control Program (OCCP)

Many odorous compounds exist in wastewater; however, gaseous hydrogen sulfide (H_2S) is the most prevalent. The compound is very objectionable when airborne, and also can be readily oxidized to form sulfuric acid (H_2SO_4) in a humid environment, such as a pump station wet-well, headspace in a gravity sewer, or at “high spots” and “transition areas” of a force main. Odors and corrosion can be minimized and almost completely prevented by chemically or biologically inhibiting the production of hydrogen sulfide, which in-turn will reduce or eliminate the generation of sulfuric acid under the correct conditions. An environment can be created that provides for a condition that is less conducive to the generation of H_2S or the release of the associated odor. However, it is not practical or cost effective to create this environment with only the addition of chemicals. Therefore a vapor phase treatment coupled with the liquid phase treatment is most commonly implemented in the control of corrosion and odor.

The OCCP evaluation was initiated with a review of the existing odor corrosion control system. Field reviews were conducted at both pump stations (COW PS 34 and COW PS 35) with City operational staff and US Filter staff present to review the existing equipment and current operational procedures. This was followed by a review of the OCCP documents provided by the City. The OCCP Contract was reviewed to ascertain the scope of the current system, the contractual arrangement with the current OCCP contractor (US Filter), and the “standards of performance” that must be achieved to be in contractual compliance. All of FY2005’s historical OCCP data was obtained and reviewed to identify significant trends or correlations between the concentrations of H_2S , the consumptions of chemicals, and the operation of the OCCP System. At the City’s request, US Filter provided an evaluation entitled “USFILTER Northeast Interceptor Corrosion Evaluation” dated April 17, 2006. This document was reviewed as well to

determine if the information obtained by US Filter correlated with the information obtained in this study.

Based on field reviews, available information, and past experience, evaluation criteria were developed that are particular to the Northeast Interceptor System. This information was presented to the stakeholders for review and comment and then revised accordingly. Several odor and control alternatives were evaluated based on these criteria to develop a list of viable odor and corrosion control alternatives which were recommended for laboratory testing. Testing procedures were developed for each alternative and the testing proceeded. Based on the results of lab testing, recommendations were provided for full scale pilot testing to verify the results of the lab testing. Recommended thresholds were then developed and compared to the contract standards of performance, leading to recommendations for OCCP system modifications as well as for bid package and contract modifications. The information obtained during this evaluation was compiled and presented in TM #2, as included in Appendix B. TM #2 provides additional in-depth information on the Operational Evaluation components.

5.1.1. Recommendations

5.1.1.1. Current OCCP

The design and operation of the current odor and corrosion controls program appears to be inadequately suited for the scope of the NEI project and currently does not address the various parameters of concern within the NEI system. In-fact, the information illustrated in Table TM 2.3 indicates that hydrogen peroxide is not meeting the systems OCCP contractual requirements at the specific sampling locations. However, the system could easily be modified to incorporate features that would certainly make the monitoring, effectiveness, and operation and maintenance of the OCCP system much more functional. We recommend the City take the following steps:

- 1.) Eliminate system “head losses” and consider changing chemicals
- 2.) Automate monitoring and chemical feed control
- 3.) Promote competition with compatible material and facilities
- 4.) Improve operational flexibility by developing a system that can be operated and maintained by the City

5.1.1.2. OCCP Contract

Our review of the US Filter contract indicates that this contract was well written and covers most of the major issues associated with the City’s OCCP system, at the time of its writing. We have identified several areas of the current contract that the City should consider modifying to update it to incorporate revisions to the OCCP system.

Accordingly, we have made comments pertaining to the existing contract using Microsoft Word’s track changes feature. Most of the proposed modifications are based on newer and more current technology and place an emphasis on providing the City with an OCCP system that is easy to operate and maintain. The ultimate goal is to provide the City with an OCCP system that the City’s staff will be comfortable with operating and maintaining within three years. Reaching this goal would eliminate the OCCP contractor all together, if desired, and reducing the costs to operate and maintain the OCCP system. One

significant modification would be to incorporate changes in the materials that the infrastructure of OCCP system is constructed of to permit the City to easily convert from one viable chemical system to another, based on changing system conditions. The contract with the proposed revisions is included as Appendix E of TM #2.

5.1.1.3. Lab Testing

Although all products evaluated in TM #2 are capable of reducing odor and corrosion in the NEI force main, our analysis suggests that only magnesium hydroxide and calcium nitrate provide a safer system, as well as higher levels of control. They appear to provide the best solution to the City for both odor and corrosion control. These chemicals require a single dosing point at each primary feed location into the NEI system. Further, these products, when dosed properly, should alleviate corrosion and odor control issues with minimal risk to City personnel and the general public. At the same time, these chemicals should reduce the consumption of the granular activated carbon (GAC) in the air scrubber systems at COW PS 34 and COW PS 35 by reducing the hydrogen sulfide gas formation.

Based on our evaluation of viable odor and corrosion control alternatives, we recommend that lab testing be performed on magnesium hydroxide and calcium nitrate. Since hydrogen peroxide is the current chemical in use with a considerable history of information, we recommend that the City consider hydrogen peroxide the “baseline chemical” that the other two chemicals are measured against. Testing should be performed on each of the three chemicals utilizing wastewater withdrawn from the worst area identified in the City’s NEI system. Very stringent laboratory conditions should be incorporated so each chemical and the testing data it produces is a true representation of how the chemical actually responds to the characteristics of the wastewater and the hydrogen sulfide it contains. Additionally, a wastewater analysis should be performed where hydrogen sulfide is introduced into the water and a baseline analysis is performed. Laboratory testing procedures are provided in TM #2.

Since the existing vapor phase system is already a carbon adsorption system, it is recommended that the City continue to use the current system and focus primarily on viable changes in the liquid phase system. If the liquid phase system is properly balanced by an appropriate chemical addition, and areas in the force main system that cause large head-losses and generate high point concentrations of hydrogen sulfide are corrected, there will also be a reduction in the consumption of the carbon that is only adsorbed in direct relationship to the amount of hydrogen sulfide in the vapor phase of the system. Therefore the City should continue with the Activated Carbon System, though they may want to consider converting to a higher capacity activated carbon media.

5.1.1.4. Proof Testing

After the laboratory testing is completed and the City has a good evaluation of the viability of each chemical, it is recommended that an actual “pilot test” be performed to confirm the information obtained in the laboratory. The current OCCP contract with the indicated recommended changes would serve as a suitable tool for establishing the guidelines for this testing. Obviously, since hydrogen peroxide has been used for many years, it is not envisioned that pilot testing of hydrogen peroxide is warranted. Because

Thioguard recently underwent an extensive pilot test on the previous OCCP contract proposal, that data is adequate to make a reasonable assessment of its performance. Therefore the pilot testing should be performed on the Bioxide if the lab testing indicates that it is a viable alternative.

5.2 Hydraulically Induced Corrosion

Areas of suspected hydraulically induced corrosion due to turbulence have been identified and investigated. Based on drawing reviews and field reconnaissance, two primary areas of concern were noted. The New Hanover County junction box, which is directly upstream of COW PS 35 and adjacent to Bradley Creek, was noted to be subject to extreme corrosion and odor. Also, the gravity section of the 20-inch force main leading into COW PS 34 was noted to be subject to substantial hydraulic turbulence. These areas have been exposed to turbulence and high velocities leading to deterioration of the structures and nuisance odors.

5.2.1. COW PS 35 Influent Junction Box

Flows from NHC sewers tributary to COW PS 35 are combined outside the site fence in an existing 7' x 7' concrete junction box. The structure has apparently been subjected to a highly corrosive environment for some time and has undergone rehabilitation in the past consisting of "shotcrete" and sprayed-on lining to avoid further structural degradation and to provide some repair to past damage. The repairs have now begun to fail as the applied coating has begun peeling away from the structure walls. The turbulent nature of the force main discharges, characterized by the approximate 2.5-foot free-fall drops, has likely resulted in the release of substantial hydrogen sulfide gas. The released gas accounts for the nuisance odors observed as well as the production of sulfuric acid, which has degraded the concrete structure.

5.2.1.1. Recommendations

Due to the turbulent, deteriorated condition of the existing junction box and the failing repairs, it is recommended that this structure be replaced with a larger junction box that revises the horizontal and vertical layout to eliminate or minimize the turbulent conditions. This will minimize the liberation of hydrogen sulfide, reducing odors and minimizing the oxidation to sulfuric acid, which will minimize future corrosion and deterioration and provide a more useful life. This should be accomplished by aligning the crowns of the influent pipes with the outlet pipe and constructing flow channels for each of the tributary sewers that smoothly slope the junction box invert between the influent gravity and force mains and the out-flowing gravity sewer. Additional information on the COW PS 35 influent junction box is provided in TM #2 (Appendix B).

5.2.2. COW PS 34 Tributary NEI Gravity Sewer and Influent Configuration

Flows from COW PS 35 are transported to COW PS 34 via a 20-inch ductile iron force main that discharges to a 20-inch gravity sewer near the entrance to Oakmont Apartments along Greenville Loop Road. This gravity sewer is directly tributary to COW PS 34. Velocities of the gravity sewer were modeled to range from 4.7 fps to 5.8 fps. However, when observed in the field, the velocities of the sewage in the drop manholes (MH A,

MH B, and MH C) appeared to exceed these modeled values due to the manhole drops. As a result, these manholes appear to have been subjected to turbulence-induced erosion and corrosion. In the past, this corrosion has degraded the concrete manholes to the point that HDPE inserts were installed to provide necessary structural integrity. It should also be noted that the 20-inch gravity sewer receiving the 20-inch force main discharge was modeled to nearly surcharge at the COW PS 35 design maximum flow. To avoid a possible surcharge situation, the gravity section near COW PS 34 should be installed as a larger diameter pipe.

5.2.2.1. *Recommendations*

We recommended that the 20" gravity sewer from the cut-in manhole near the entrance of Oakmont Apartments to manhole C on Pine Grove Road be rehabilitated with cured in place pipe (CIPP). We further recommend that 24" gravity sewer be installed from manhole C to the COW PS 34 junction manhole. This combination eliminates drops and resulting turbulence and reduces the liberation of hydrogen sulfide gas. This opinion of probable construction cost for this combination is \$192,000.

Additional information on the COW PS 34 tributary gravity sewer and influent configuration is provided in TM #2 (Appendix B).

5.3 Air Release Valve Condition and Operation and Maintenance Evaluation

Both water and wastewater contain air that has been entrained as tiny bubbles. This entrained air is released into the entire length of force main or water main during normal operations of the system. In wastewater, where there is the presence of hydrogen sulfide (H_2S), the entrained air has the potential to be released as H_2S gas which can be oxidized to form highly corrosive sulfuric acid above the wastewater surface.

Entrained air has the potential to be highly corrosive and result in deteriorated pipe. It also directly affects the hydraulic performance of the force main and the pump station. Air continually comes out of solution and is released into the force main and accumulates in pockets at the high points in the force main system. It has been well documented that flow capacities in a force main can easily be reduced by 5% to 10% due to even a small pocket of gas build-up. This build-up creates a potentially highly corrosive pocket of hydrogen sulfide gas and reduces the efficiency of the pumping system, robbing it of potential capacity and at the same time increasing the overall energy costs. Even a small loss of efficiency has the potential to have significant financial implications.

It is good engineering practice, as well as a requirement by the North Carolina Department of Environment and Natural Resources (NCDENR), to install air/vacuum release valves at the high points in force mains to eliminate the generation of these pockets of air. Air/vacuum release valves have three primary, critical functions. Function one is to permit the large volumes of air in a force main to be automatically released or exhausted through a properly sized orifice as the incoming fluid fills the force main. The second function is to vent the entrained air that is continually released into the fluid. The

third function is to permit air back into the force main when the system is not in operation.

The existing ARV assemblies on the NEI system were located in the field and used as initial test sites for the pipeline ultrasonic thickness testing. Each ARV vault and assembly was observed and the condition and other pertinent data documented. Construction of the ARVs was consistent with the exception of one that had been replaced. ARV vault numbers 1, 2, 3, 5, 6, 8, 9, 10, 11, and 12 were observed to be 8-inch concrete masonry unit (CMU) box structures built on a poured slab with a precast top. ARV #4 has been replaced with a 4-foot diameter concrete manhole. ARV #7 has been removed. All air release valves, with the exception of one that has been replaced in ARV#1, appear to be the Val-Matic Model #48. Specific information on each ARV vault, along with pictures, is provided in the ARV Data Sheets in Appendix G of TM #2. A summary table is provided as well.

In addition to the evaluation of the current ARV assemblies, a recommended ARV operation and maintenance program was developed. The program contained procedures and recommended frequencies for servicing the ARV assemblies to help ensure proper function.

Our extensive experience with the design and construction of large pump stations and force mains has led us to discover that most municipalities don't maintain their air/vacuum release valves because they are either inconvenient to access, or are located in a single vault or manhole that is very "nasty" for maintenance personnel to enter. In addition, the older design of air/vacuum release valve manholes, which simply placed a hole in the base (if there was a base) filled with stone below the manhole, are now being considered a source of wastewater discharge (an SSO), even in small amounts. This is also a location where ground water can easily infiltrate the air/vacuum manhole and either make it very difficult to maintain or render it totally inoperable.

Kimley-Horn has developed a new approach to the air/vacuum release valve maintenance problem by designing a dual compartment structure (see Figure TM 2.12) with an integral dry side and a wet side. This unique design permits maintenance workers to access the mechanical area of the air/vacuum release valve without unnecessarily having to come in contact with the sewage. The wet side is designed to permit the easy wash down and removal of any "blow-by" of the sewage or back-flushing water by the use of a vacuum truck, which almost every municipality already has. The design provides for a contained wet side so there is a highly reduce potential for an SSO.

We recommend that this type of assembly be installed on all new force main systems to encourage rather than discourage maintenance, allow for easier maintenance, keep structures cleaner, eliminate groundwater, and minimize the potential for an SSO. We also recommend that this type of assembly replace existing assemblies as necessary to avoid the above noted conditions.

Due to the corrosive nature of the environment in which these devices are installed, whether installing new assemblies, or replacing or retrofitting existing assemblies, we also recommend considering the more corrosive resistant materials such as stainless steel and plastic.

5.3.1. Recommendations

For the NEI System, the following specific actions are recommended as part of the DIRP to address immediate needs. These improvements are acceptable for an interim period of 2 to 3 years until the system is completely rehabilitated or expanded.

- Implement and strictly adhere to an ARV Operation and Maintenance Program including the ARV O&M log as provided above.
- Replace all air release valves with combination air/vacuum pressure release valves in accordance with the recommendations of the surge analysis.
- Replace the tapped blind flange, nipple, and gate valve assembly with a new 2-inch tapped flange, a 300 psi ball corporation stop, and coupling.
- Raise any vaults that are below grade to grade.
- Install a 6-inch PVC vent to the right of way line on all vaults.
- Consider either replacing the access ring and covers with aluminum 3x3 single leaf or 4x4 double leaf H-20 rated hatches or replace the tops with precast tops with aluminum hatches for easier access and maintenance.
- Replace existing ARV#4 with the detail in Figure TM 2.12 below.
- Replace the 8-inch CMU wall that is collapsing in ARV#11.

In lieu of the preceding recommendations, the City could proceed with the following long term actions that are recommended to extend the useful life of the NEI system:

- Replace all existing ARV structure/assemblies with the detail in Figure 2.12.
- Implement the recommendations of the surge model analysis.
- Strictly adhere to the Operation and Maintenance Program implemented as part of the interim recommendations.

Without functioning air release valves, performance and long term reliability of a wastewater force main system can be compromised. The expulsion of trapped air and gases is essential to maintaining pipeline integrity and providing both maximum flow capacity and higher operating efficiencies of the system. No matter the style of valve selected or configuration installed, adherence to a regular operation and maintenance regimen is essential to insuring proper performance and reliability of the system.

Additional information on the air release valve condition and operation and maintenance is provided in Technical Memorandum #2 (Appendix B).

5.4 Surge Model Evaluation

Surge protection is integral to providing a system that operates efficiently, reliably, and at maximum design conditions.

Under normal operating conditions, wastewater pumping systems operate at either a steady state condition (constant speed pumps) or a slowly varied condition (variable speed pumps). Constant speed pumps deliver a constant flow and head, while variable speed pumps deliver a slowly adjusted flow and head. Changes in system operation such as sudden pump failure, power failure, pump restart, and sudden valve closure can cause rapid changes in the velocity of the wastewater within the system. Velocity changes can cause pressures to fluctuate and vapor/air pockets to form and collapse at high spots along the force main, which in turn can generate large surge pressures. Lack of surge protection equipment, or improper sizing and location of surge protection equipment, may cause poor system performance, pipe failure, or mechanical equipment failure.

Surge models have been developed for the NEI to complete the following tasks:

- Evaluate potential surge pressures to aid in evaluating the adequacy of deteriorated pipe
- Evaluate the adequacy/performance of the existing surge protection equipment such as air release valves, combination air/vacuum valves, or surge relief valves
- Identify modifications that will minimize surge pressures and improve the operation and reliability of the system

5.4.1. Recommendations

The following actions are recommended as part of the DIRP to address immediate needs:

1. Install combination air/vacuum valves with a 1-inch large orifice and 3/16-inch small orifice at all current ARV locations (ARV's #8-#12). The 1-inch combination ARV valves will reduce the anticipated overall total pressure under surge conditions approximately 45% and reduce the extent of full vacuum pressure from approximately 92% of the system to approximately 19%
2. Install combination air/vacuum valves with a 1-inch large orifice and a 5/16-inch small orifice at current ARV locations (ARV #1-#4 and #6) and proposed locations within the Shipyard relocation project. The 1-inch combination ARV valves will reduce the anticipated overall total pressure under surge conditions approximately 58% and reduce the extent of full vacuum pressure from approximately 100% of the system to approximately 13%

Additional information on the surge model analysis is provided in TM #3 (Appendix C)

5.5 Evaluation of Daily Pump Station Data Collection and Trending

Review of the current City daily pump station data form indicates that many of the typical parameters necessary for daily maintenance activities are already being tracked. Between this data and the data recorded by the SCADA system, a fairly comprehensive performance and maintenance history can be generated for the respective pump stations. The existing form is included as Appendix H in TM #2.

5.5.1. Recommendations

We recommend the following additions or modifications to the Daily Pump Station Maintenance Log:

- Incorporate entries for pump run time and discharge pressure readings (add discharge pressure gages to all pump discharges). Such information recorded in the field will be beneficial to compare with SCADA recorded data.
- Provide entry for a “smell test” to help correlate odor patterns. Such data may be useful to qualitatively track odor control process success. This will particularly help with COW PS 35 and its proximity to heavily traveled Oleander Drive. It may be beneficial to also include an item to make sure dumpsters are monitored for being covered as well as ensuring they are not overflowing or “debris” is not missing the receptacle.
- Include an entry for visual indications of high water or possible overflows either in yard manholes or screening chamber (i.e. high water marks or debris).
- The references to checking the grit removal equipment should be taken off of the checklist as this equipment is no longer in use.

5.6 SCADA System Monitoring and Control Evaluation

Review of the existing SCADA system capabilities indicates that the City has the ability to monitor and record a great deal of information from COW PS #34 and #35. The current system monitors approximately 150 tags or items such as pumps, ventilation fans, and generators. Such information is a valuable tool for ensuring reliability of the system and allows for “real time” monitoring. A typical screen shot and list of pump station monitored data for both COW PS 34 and COW PS 35 is included Appendix I of TM #2.

5.6.1. Recommendations

We recommend the following additions or modifications to the SCADA monitoring system:

- Incorporate pressure gauge readings into the routine monitoring display items.
- Add monitoring item for the station’s respective proposed flow meters. These readings will prove invaluable to gauge the efficiency of pumps as well as immediately alert operators of anomalies.
- Perhaps a normal operating “flow envelope” could be developed from a diurnal curve tailored to the system. The curve could serve as a baseline for comparison to any flow conditions encountered. Should anything outside the areas of normal operation occur, a notice would be generated within the monitoring system to trigger more scrutiny by operators.

5.7 Easement Maintenance and Management

To develop an easement maintenance and management plan, the Northeast Interceptor (NEI) route was reviewed to evaluate the location of existing or required easements, condition of those easements, and encroachments into those easements by vegetation, structures, and other utilities that could be impairing the NEI’s integrity and reliability. An Easement Management Plan was then developed that addresses

maintenance procedures, utility encroachments, accessibility, permitted land uses, and permitted structures and vegetation.

Based on a field review of the COW PS 35 force main, as located by the City, it appears that the force main route lies entirely within NCDOT and City rights of way and no easements exist or are necessary. However, it is recommended that existing vegetation that has overgrown to encroach into the right of way be removed to provide better access to the force main and prevent any future issues.

The 20-inch gravity section of the NEI upstream of COW PS 34 is located within a 15-foot dedicated utility easement through the Oakmont development. This easement is characterized by numerous encroachments such as fences, plantings, and possibly house footings.

The 24-inch force main from COW PS 34 to the Southside WWTP is primarily located within existing City and NCDOT rights of way, although several sections are located in dedicated utility easements. Easements varied from wet areas along Hewlett's Creek to parking lots and open cross-country areas.

Following review of the existing easements along the NEI route, an Operational Easement Management and Management Plan was developed that addresses maintenance procedures, utility encroachments, accessibility, and State mandated requirements. Also, an Easement Maintenance and Management Policy was developed to help regulate and standardize easement maintenance, accessibility, and permitted uses or encroachments.

5.7.1. Recommendations

We recommend the following actions to address the issues identified above:

- Implement an operational easement management and maintenance plan.
- Adopt a formal easement encroachment policy clearly specifying permitted encroachments and procedures for City authorization of such requests.
- Remove all trees from easements.
- All water and sewer lines need to be readily accessible. All easements should be traversable to allow for maintenance and monitoring.
- Do not allow unauthorized encroachments from private owners onto easements (fences, buildings, and plantings) that may impede inspection and maintenance of the utilities.

Additional information on easement maintenance and management is provided in TM #2.

6 Deficiency Identification and Repair Program

Initial investigations for the pipeline condition assessment began with a review of the project history with the City of Wilmington operational and engineering staff. This information was supplemented with information provided by the Town of Wrightsville Beach, New Hanover County, and the North Carolina Department of Environment and Natural Resources regional Water Quality staff. Additional information was obtained through a review of historical records, construction record drawings, additional interviews with operational staff, and field visits. Information obtained on the historical failures, rehabilitations, replacements, and reroutings were cataloged as indicated in Technical Memorandum #4 Tables TM-4.1 and TM-4.2 (Appendix D).

The hydraulic profile of each force main was plotted as shown in Figures TM-4.6 and TM-4.7 (TM #4) based on the construction record drawings, to identify potential problem areas. The historical failures have been included along the profile. The location of these past failures indicates that the past corrosion related problems have occurred at locations where hydrogen sulfide gas typically accumulates. These areas include high spots where air and gases, such as hydrogen sulfide, can accumulate and remain if ARVs are not functioning properly or were not located properly. They also include gravity flow and transitional areas of the pipeline where the pipe is partially full during operation and relatively empty when the pump station is not operating. These areas are depicted in red on the profiles and are the areas of higher probability for future problems.

Based on the initial investigations, it appeared that all the necessary conditions for hydrogen sulfide corrosion existed within the force main, and the pipe deterioration was the result of internal corrosion. Once this determination was made, a method for investigating the condition was developed.

6.1 Testing Options

Several methods are available to aid in identifying deficiencies within a pipeline. They include conventional CCTV inspection, sonar and laser profiling, pipe coupon extraction, and ultrasonic pipe wall thickness testing. CCTV, sonar, and laser profiling require insertion of equipment into the pipeline. These types of equipment are most useful in situations where flows are not under pressure, access is readily available (e.g., manholes), and service can temporarily be interrupted or flow rerouted.

Ultrasonic testing however can be performed completely from the exterior of the pipeline with no interruption to system operation. Also, no mechanical modifications (e.g., cutting in valves, tees, etc. for bypass pumping) of the potentially fragile pipeline are required. For these reasons, the use of non-destructive ultrasonic pipe wall thickness testing coupled with coupon extraction was viewed as the best alternative for investigation of the NEI pipeline.

6.2 Deficiency Calculations

As field investigations began, the stakeholders were consulted to establish criteria for classification of pipe deficiencies based on the measured thickness. These classifications were then used to categorize pipe that was in imminent danger of failure, pipe that was in urgent need of repair, pipe that should be replaced or rehabilitated, and pipe that was acceptable for continued use. Classifications of deficiencies were established and approved by the NEI Stakeholders as indicated in Table 6.1 below.

Deficiency Classification	Recorded Thickness
In imminent danger of failure:	Factor of Safety (FS) < 1.5
In urgent need of repair:	FS > 1.5, but the thickness is less than the casting tolerance minus the serviceability tolerance
To be rehabilitated or replaced:	The thickness is between the casting tolerance and the casting tolerance minus the serviceability tolerance
Acceptable for continued use:	The thickness is within the casting tolerance

Table 6.1 - Deficiency Classifications

The following are recommendations for replacement or rehabilitation.

Deficiency Classification	Recommendations
In imminent danger of failure:	Repair immediately when identified.
In urgent need of repair:	Repair/replace as part of the Deficiency Identification and Repair Program (DIRP)
To be rehabilitated or replaced:	Rehabilitate in the near future (3-5 years)
Acceptable for continued use:	Rehabilitation or replacement not currently recommended

Table 6.2 – Deficiency Classifications Recommendations

Justification for these classifications and recommendations are provided in TM #4 included in Appendix D.

6.3 Testing Strategy

Testing began at the ARV valves (high points) since it was anticipated that the greatest corrosion would occur at these locations and since the pipe was more accessible with little to no excavation. If the thickness readings in the ARV vault were within the casting tolerance, excavations were made outside of the vault to confirm that it was at the high point in the line. If it was not at the high point, tests were taken at the higher elevations to determine if gas was collecting above the valve elevation resulting in corrosion at that location. If the thickness readings inside the vault were below the casting tolerance minus the serviceability tolerance, the pipe was excavated outside the vault to delineate the extents of the corrosion.

The investigation continued upstream and downstream until pipe was found within the casting tolerance minus the serviceability tolerance to bracket the extent of pipe that was “in urgent need of repair”. Further thickness testing was performed at locations identified as potential problem areas such as areas that were potential high spots if the sewer was installed based on a standard depth rather than the design grades. Additional areas that were investigated included one of the New Hanover County taps onto the 20-inch force main on Greenville Loop Road and areas where newer PVC pipe joins the original ductile iron pipe.

6.4 Testing Results

Ultrasonic thickness testing was performed at a total of 44 sites. The test sites are identified on the force main profiles in TM #4 Figures TM 4.6 and TM 4.7. Each site is color coded to reflect the deficiency classification category. At each site, tests were generally performed at 2-3 locations, typically on each side of air release valves in vaults and in 3 locations in pits. At each location, tests were performed around the circumference of the pipe from clock position 7:00 clockwise to clock position 5:00, typically at the hour positions. Results of the testing are tabulated in Table TM-4.6 (20-inch force main) and Table TM-4.7 (24-inch force main).

6.4.1. NEI 20-inch Force Main Testing Results

Testing on the 20-inch force main began with testing in ARV Vaults No. 8-12. Thickness readings in Vaults 10, 11, & 12 were outside the casting tolerance but within the serviceability tolerance, indicating minimal to moderate corrosion. Thickness readings in Vaults 8 and 9 were well within the casting tolerance indicating little, if any corrosion. Pits were then excavated outside each vault to define the limits of corrosion or confirm that the ARV was located at the high point. Pits were also excavated at the transition from ductile iron to PVC at Station 10+45 to determine if all corroded pipe had been removed, and at the New Hanover County Greenville Trailer Park Force Main connection to inspect the connection and test downstream to determine if the turbulence created at the connection was resulting in corrosion. A total of 28 sites were tested with 2-3 locations at each site. Additional information on the testing results is provided in TM #4 included in Appendix D.

6.4.2. NEI 24-inch Force Main Testing Results

Testing on the 24-inch force main began with testing in ARV Vaults No. 1-3 and 5. Testing was not performed at ARV Vault No. 6 until later due to the difficult accessibility. Testing was not performed inside ARV Vault No. 4 since the ductile iron pipe had been replaced with PVC. A total of 16 sites were tested with 2-3 locations at each site. Of the 16 locations, only two indicated a thickness outside the casting tolerance.

Thickness readings in Vaults 1, 2, and 3 were well within the casting tolerance indicating little, if any corrosion. Thickness readings in Vault 5 were outside the casting tolerance but within the serviceability tolerance, indicating minimal to moderate corrosion. Pits were then excavated outside Vaults 1-3 to confirm that the ARVs were located at the high point.

Pits were also excavated at the transition from ductile iron to PVC at Station 142+43 to determine if all corroded pipe had been removed, and along Stonewall Jackson Avenue to investigate the potential for corrosion at high spots without air release valves. Additional information on the testing results is provided in TM #4 included in Appendix D.

6.5 Conclusions and Recommendations

The ultrasonic thickness testing of the NEI force main indicates a variety of conditions throughout the NEI force mains. Generally the 24-inch force main appears to be in good condition with a few exceptions as indicated below. The 20-inch force main exhibits more corrosion though only 5% is classified in urgent need of repair (12% to be replaced to be conservative).

The following are general recommendations for improvements to the Northeast Interceptor System.

- 1.) Ensure that all future connections or modifications to the exiting force mains are made with appropriate corrosion resistant fittings with corrosion resistant components (bolts, etc.).
- 2.) Implement the recommendations of the Operational Evaluation (TM #2).
- 3.) Implement the recommendations of the Criticality Assessment (TM #5).
- 4.) Prior to installing any tapping sleeve or line stop for bypass pumping operations, the proposed location to receive the sleeve should be tested for thickness with an ultrasonic device to verify that there is sufficient pipe wall thickness to accept the sleeve. It is recommended that this thickness be within the casting tolerance of the pipe.

6.6 COW Pump Station 35 Force Main (20-inch)

The ultrasonic thickness testing of the 20-inch force main from COW PS 35 to COW PS 34 indicates that the force main has approximately 800 LF that is in urgent need of repair (approximately Sta. 98+27 to Sta. 106+27) and five areas in need of rehabilitation or replacement. Corrosion in these areas is attributable to hydrogen sulfide gas that likely collected when the pumps shut down, particularly in the early life of the force main when flows were low. The valves in these locations likely became inoperable as well allowing hydrogen sulfide gas to collect and not be expelled.

It is recommended that the replacement of the 800 LF that is in urgent need of repair be extended to 2,000 LF for the following reasons:

- 1.) Thickness readings have varied greatly along this section of force main. Highly localized corrosion or pitted areas are adjacent to areas exhibiting little to no loss of material making the corrosion difficult to locate.
- 2.) This portion of the force main is most susceptible to corrosion from high concentrations of hydrogen sulfide.
- 3.) This portion of the force main was installed with what appears to be an epoxy liner which is failing, resulting in sporadic corrosion that is difficult to locate.

In some locations, areas classified as acceptable for continued use have readings within the casting tolerance but very low in the range, such as pits B and D on either side of ARV #11. This indicates that the corrosion between the locations has encroached into these areas but is not significant. We recommend extending the rehabilitation or replacement beyond these areas as well to extend the useful life of that portion of the force main.

The following specific actions are recommended as part of the DIRP to address immediate needs.

- 1.) Replace all air release valves with combination air/vacuum pressure release valves in accordance with the recommendations of the Surge Analysis (TM #3).
- 2.) Replace approximately 2,000 LF of DIP with PVC at ARV No. 10 from Station 90+00 to Station 110+00 and replace ARV No. 10. If there is significant corrosion at Station 110+00, continue on to the Greenville Trailer Park force main connection at Station 116+45.
- 3.) Re-install an air release valve at Station 7+50.
- 4.) Rehabilitate/replace gravity sewer per the recommendations of the Operational Evaluation (TM #2).

The following specific actions are recommended within a 3-5 year period.

- 1.) Replace or rehabilitate approximately 300 LF of DIP with PVC at ARV No. 12 when the ARV vault is replaced. If replaced rather than rehabilitated, adjust the length based on visual observation of the pipe being removed.
- 2.) Rehabilitate approximately 850 LF of DIP at ARV No. 11 (Sta. 126+00 to Sta. 134+50) when the ARV vault is replaced. As an alternate, replace with PVC and adjust the length based on visual observation of the pipe being removed.
- 3.) Rehabilitate approximately 650 LF of DIP from Sta. 110+00 to Sta. 116+50 when the ARV vaults are replaced. As an alternate, replace with PVC.
- 4.) Rehabilitate approximately 2,350 LF of DIP at ARV No. 9 (Sta. 126+00 to Sta. 134+50) when the ARV vault is replaced. As an alternate, replace with PVC.
- 5.) Rehabilitate approximately 650 LF of DIP at the transition from DIP to PVC from Sta. 10+45 to Sta. 16+95. As an alternate, replace with PVC and adjust the length based on visual observation of the pipe being removed.

6.7 COW Pump Station 34 Force Main (24-inch)

The ultrasonic thickness testing of the 24-inch force main from COW PS 34 to the Southside WWTP indicates that the force main is generally in good condition with the exception of the portion currently being replaced along Shipyard Boulevard. A reduction in thickness below the casting tolerance was only recorded at two locations, one of which (ARV #5 along Shipyard Boulevard) will be addressed when this section is replaced as part of the project currently underway. The other location is adjacent to a previous replacement.

The good condition overall is largely due to the fact that the portion of the force main that is most susceptible to corrosion from high concentrations of hydrogen sulfide has already been replaced with PVC (Station 107+16 to Station 142+39). The remaining portion of the force main should remain full as long as entrained air and gases are expelled by the air release valves. If these areas of the force main remain full, the conditions necessary for hydrogen sulfide corrosion will not exist in these areas. There is no air space for the release of hydrogen sulfide gas to the vapor phase and no opportunity for the oxidation of hydrogen sulfide gas to sulfuric acid. There is the opportunity for air to enter the force main through air vacuum valves to break vacuums at high points; however, with variable speed pumps that operate most of the time, and air vacuum valves to release this air as the pumps cycle on, any gases which may accumulate will be expelled after a short period of time. Improvements to the odor corrosion control program as recommended by this study (TM #2) will also reduce the formation of hydrogen sulfide gas, additionally reducing the potential for corrosion.

The significant corrosion problems along Shipyard Boulevard obviously indicate that this portion of the force main has had air pockets form where hydrogen sulfide gas collected

and was oxidized to sulfuric acid, rather than remaining full as described above. There are two potential reasons for this condition. One is that the air release valve did not operate properly and release gas as it was formed. If this were the case though, it would be reasonable to expect that the corrosion would be more severe closer to the ARV rather than 60-90 feet downstream, although a bubble of gas could get pushed past the valve if not expelled. The fact that the corrosion is much more severe 60-90 feet downstream of the ARV points to a second reason; that the ARV is not located at the high point in the force main and air and gases are accumulating at a high point 60-90 feet from the ARV. This theory is further supported by the fact that, according to City staff, ARV #4 was not located at a high spot, resulting in the failures at this location; therefore there is the likelihood that others might not be as well. It is also possible and likely that this corrosion was the result of a combination of both conditions. In order to verify this theory, the existing force main will need to be excavated at the location of the failure and surveyed to determine the elevation relative to the ARV. Due to the extremely deteriorated conditions of this force main however, it should not be excavated until it has been abandoned.

The investigations of the ARV locations and potential high spot locations as described above, indicate that corrosion at high points is not an issue at those locations. Some further investigation is recommended to verify this at other less likely locations as indicated below. We recommend sonar or laser profiling to identify corrosion in potential high spots.

The following specific actions are recommended as part of the DIRP to address immediate needs.

- 1.) Replace all air release valves with combination air/vacuum pressure release valves in accordance with the recommendations of the Surge Analysis (TM #3).
- 2.) Replace ARV #4 with the ARV detailed in Figure TM 2.12 as recommended in the Operational Evaluation (TM #2).
- 3.) Survey the abandoned force main along Shipyard Boulevard to locate the high spot in the vicinity of ARV #5.

The following specific actions are recommended within a 3-5 year period.

- 1.) Replace 60 LF of DIP with PVC at the transition from DIP to PVC at Station 142+43.
- 2.) Replace ARV Nos. 1-3 and 6 with the ARV detailed in Figure TM 2.12 as recommended in the Operational Evaluation (TM #2). Relocate ARV #6 to a more accessible location at the end of Cascade Drive.
- 3.) perform sonar or laser profiling from Station 264+00 (Cascade Drive) to Station 324+37 (COW PS 34) to locate any potential repairs that have been made.
- 4.) Perform sonar or laser profiling from Station 90+00 to Station 110+00 and Station 225+00 to Station 250+00 to investigate potential corrosion at potential high spots.

7 Corrosive Soils Investigation

A corrosive soils investigation and analysis was conducted as part of this study by the Ductile Iron Pipe Research Association (DIPRA). Corrosive soil conditions can lead to corrosion and degradation of the exterior of the ductile iron pipeline, reducing the reliability of the force main. DIPRA employs the use of a standardized test method referred to as the Design Decision Model™ (DDM™). This analysis evaluates resistivity, pH, redox, sulfides, and moisture content for the likelihood of creating an environment in which ductile iron pipe (DIP) could experience exterior corrosion. Within the parameters of the DDM™, there are five levels of anticipated risk for corrosion. Level one indicates that no external corrosion protection other than the manufacturer applied protective coating will be required. Levels two through four recommend that polyethylene encasement with increasing requirements for “jumper connections” and/or cathodic protection. Level five, which indicates the most severe corrosive conditions, recommends comprehensive cathodic protection.

Soil samples for the investigation were taken from borings located approximately every 500-800 feet along the NEI force main route. Samples were taken approximately at the depth of the force main with a trailer mounted drill rig by DIPRA and supplemented with some samples retrieved by Kimley-Horn. The soils analysis was performed by DIPRA at their laboratory facilities. A report including their findings, conclusions and recommendations was provided and is included as Appendix F.

The findings of the report indicate that all but approximately 7,050 linear feet of the pipeline would be sufficiently protected if the pipe were installed by the traditional “cut and cover” method with only the standard manufacturer’s coating. Fairly mild corrosive soils were found in three locations and classified as level 2 susceptibility. This classification indicates that these areas should be adequately protected with standard polyethylene encasement. One of these areas was located along the 20-inch force main in an area slated for rehabilitation near Sta 83+50 to Sta 93+50. Due the scheduled rehabilitation and the mild corrosive conditions, it was determined that testing in this location was not necessary.

Corrosive soils were also noted along the 24-inch force main located in the easement paralleling Hewlett’s Creek (Sta 267+00 to Sta 323+50). According to the as-built drawings, the pipe in this area was encased in polyethylene. The pipe exterior was found in good condition when the repairs were made near Warlick Drive, indicating that the encasement has performed well. However, there is some concern that the installation of the Hewlett’s Creek gravity sewer, which is in extremely close proximity to the NEI force main, could have damaged the polyethylene liner in places.

The other area identified with mildly corrosive soils was located near Sta 55+00 to Sta 59+00 on the 24-inch force main along Independence Boulevard. The route of the proposed force main will parallel the existing force main. Due to the mildly corrosive environment, the depth of the force main, and wet soil conditions, we recommend that the

external condition of the pipe be inspection at the time of the installation of the parallel force main.

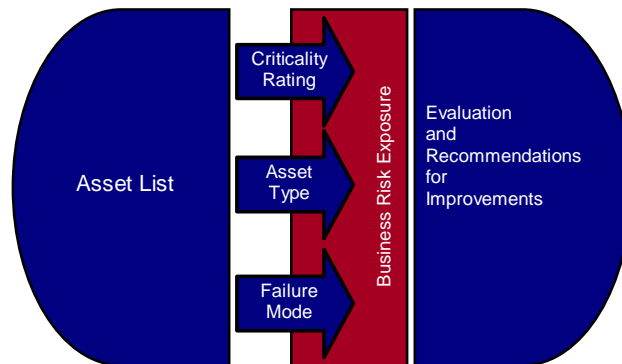
8 Criticality Assessment

The Northeast Interceptor (NEI) is the critical link in conveying wastewater flow from Wilmington, New Hanover County, and Wrightsville Beach to the Southside WWTP. The NEI includes the largest and 3rd largest wastewater pump stations in the collection system and includes approximately 49,000 LF of force main. The complexity, size, expansiveness, and proximity to important water resources lend itself to a criticality assessment to determine which elements of the system are most important to maintain reliable wastewater service (Appendix E).

8.1 Methodology

To understand the individual importance of each element or sub-system of the NEI, a list of all the major assets was developed. Each asset was reviewed with the NEI team members and a criticality rating was assigned. In addition, each asset was assigned a “type” category and a “most likely mode of failure” category. Every asset has a certain life span and will fail at some point. As such, business risk level criteria were established to reliably meet the operational goals. Asset criticality, asset type category, and asset failure modes were reviewed in light of the acceptable business risk exposure criteria to establish recommendations and prioritize improvements to deficient items. Figure 8.1 shows the interrelated nature of the six step process used on this project.

Figure 8.1 – Criticality Evaluation Model



8.2 Recommendations

Observations and recommendations of the criticality assessment should be implemented as follows:

1. Define the service area and future design capacity.
2. Determine the pipeline solution.
3. Evaluate key assets in relation to future operating conditions and implement recommendations listed in Tables TM5.4 and TM 5.5 in TM #5 to address deficient critical assets.
4. Prepare the Asset Failure Action Plan for “Category Factor 1” assets.
5. Continue proper operation and regular maintenance on all equipment not programmed as run-to-failure equipment.
6. Inspect assets and monitor key asset parameters. Proactively repair problematic elements to reduce likelihood of failure.

9 Reliability Improvement Alternatives

9.1 Alternatives Evaluated

The realm of reliability improvements include recommendations discussed in the field deficiency investigation, operational evaluation, and criticality assessment, all of which must be implemented within the framework of the selected alternative to address the NEI capacity issues as discussed in the capacity analysis. There were 24 different approaches formally considered for dealing with the NEI capacity issues. Based on the goals for improved reliability, event management, and cost considerations, two viable alternatives emerged from the capacity analysis for consideration. Recommended operational improvements are not repeated here, but should be implemented as part of the selected alternative.

9.2 Viable Alternatives

For consistency, the alternative identification numbers are kept the same as that used in the supporting technical memorandum. Both viable alternatives are the “base” option under the respective alternative.

The two viable alternatives generally include the installation of a parallel force main from COW PS 35 to the Southside WWTP. Capacity improvements will be necessary at COW PS 35 and to the force main conveyance system. Critical component and operational improvements will be required at both pump stations and along the existing force main. Under alternative 4 the projected flows from the service area exceed the site capacity of COW PS 35, so this alternative includes recommendations for a new re-pump facility that would by-pass a portion of the flow around COW PS 35.

The City of Wilmington is underway with design of improvements to COW PS 34 and COW PS 35. At the time of writing this report, the project is about 90% complete and scheduled for construction commencement in November 2006. To avoid double-counting recommended improvements, the recommendations listed under each viable alternative below do not include current problems which are planned for replacement under the City’s PS 34 and PS 35 improvements project.

9.2.1. Alternative No. 3

9.2.1.1. Description

This alternative includes recommendations to handle the build-out flows from Major Basins III, IV, and V as previously discussed. Improvements include flow expansion, operational improvements, and criticality improvements to COW PS 35; installation of a new force main from COW PS 35 to the Southside WWTP with periodic interconnections with the existing NEI force mains; and operational and criticality improvements to COW PS 34.

Improvements at COW PS 35 will connect one pair of pumps with the existing force main and the other pair of pumps with the new force main. Since each pair will act as a separate pump station, firm pumping capacity can be achieved without having any single pump sized for the total peak flow coming into the station.

Implementation of this alternative will include the major components tabulated below.

- | | |
|-----------------|---|
| COW PS 35: | <ul style="list-style-type: none"> - Replace Pump #3 and Pump #4 and install a 24-inch pump station header with flow meter. Electrical capacity improvements will include up-sizing the service entrance, stand-by generator, and automatic transfer switch. - Replace the County junction vault due to severe corrosion. - Implement SCADA Improvements - Proceed with bench testing and implement changes to OCCP |
| COW PS 34: | <ul style="list-style-type: none"> - Replace the automatic transfer switch (ATS) with an ATS with manual by-pass for temporary operation in the event of ATS electronics failure. - Work with Progress Energy to clear trees from the power easement. - Implement SCADA Improvements - Proceed with bench testing and implement changes to OCCP |
| New Force Main: | <ul style="list-style-type: none"> - Install approximately 49,000 LF of 24-inch force main. Pipeline corridor should be established in a manner to facilitate periodic pipeline interconnects. Force main interconnects between COW PS 34 and COW PS 35 should include flow control valves. |
| Ex. Force Main: | <ul style="list-style-type: none"> - Raise top of ARV vaults above grade for maintenance access. - Replace all ARV's and connecting piping. - Install vent pipe on each ARV vault. - Replace ARV vault #4. - Repair ARV #11 vault collapsed wall. - Remove all trees from pipeline easements. - Replace COW PS 34 Junction Box (MH A) - Replace/Rehabilitate gravity section upstream of PS 34 - Replace 2000 LF of 20" force main per thickness testing - Internally evaluate and rehabilitate existing following installation of parallel line - Relocate approximately 7,000 LF of 20-inch force main along Hewlett's Creek to the new parallel force main route. |

Modifications at COW PS 35 can be performed in a particular sequence to avoid costly by-pass pumping while maintaining existing firm pump capacity. Once the new force main is ready for service a new 24-inch header pipe can be constructed on the east wall of the pump station. Pumps #1 and #2 would be removed and placed in storage, and the new largest pumps would be installed in the available pump slots and connected to the new force main. Once the new pumps are operational, the old pumps #3 and #4 can be

removed and the existing pumps #1 and #2 re-installed in the available pump slots. Since the motor horsepower will not exceed 200 hp the VFD drives being installed in the City's PS 34 and PS 35 upgrade project should be sufficient, but they will need to be re-fed to the new motor locations.

In addition to the modifications on the NEI system, about 5,100 LF of 16-inch force main will need to be installed between the intersection of Westover Road and Military Cut-off Road and the Ogden Interceptor to divert flow from NHC PS 77 to the 36-inch diameter Ogden Interceptor. The County is currently evaluating the capacity of the Ogden Interceptor to determine if improvements to the interceptor are necessary to implement this alternative.

With the connection of the County's 16-inch force main to the Ogden Interceptor, there is an opportunity to perform piping modifications at COW PS 34 and COW PS 35 to allow flow reversal in the force mains for event management. A preliminary evaluation of how the interconnects could be made indicated that the site piping work would be very costly due to the number of valves and fittings required. Since the recommended system will provide a second force main and the new force main from COW PS 35 will provide by-pass capabilities around COW PS 34 for event management, we do not recommend expending funds for these flow reversal interconnections.

Since flow from Major Basin II is diverted away from the NEI under this alternative, a capacity expansion of the Southside WWTP could be delayed longer, in comparison to the other alternative in consideration. It is expected that an expansion of the Southside WWTP would trigger much tighter NPDES limits from the NC Division of Water Quality as evidenced by the recently permitted Northside WWTP capacity expansion. Considering the higher treatment requirements, it is expected that the cost to treat wastewater at the Southside WWTP would increase significantly with the next expansion. With the escalation of construction costs over time, the treatment costs at the Southside WWTP could exceed that at the Northside WWTP.

9.2.1.2. Preliminary Routing Analysis

Routing is critical for feasible construction of a new 24-inch or 30-inch force main. The route of the existing NEI encompasses difficult terrain (swamps), heavily traveled and urbanized rights of way (Greenville Loop, Oleander, and Shipyard), and other utilities competing for space. Multiple alignments were identified and evaluated to preliminarily select the more feasible route. The evaluation considered existing utilities, easement requirements, interconnection opportunities, route accessibility for maintenance, and possible interconnections between the existing force main and the proposed force main. Based on this preliminary evaluation, the preferred routing combination is Section 1A, Section 2C, and Section 3 as shown on Figures 9.1, 9.2, and 9.3.

The preferred route originates at COW PS 35 and extends along Circular Drive and Park Avenue. This portion of the alignment is characterized by residential housing, commercial sites, and several underground utilities within the right of way. The next portion of Section 1A crosses Oleander Drive at French Road and Willow Woods Drive.

This area is characterized as developed residential with existing utilities present within the right of way. From Willow Woods, the alignment follows Clearbrook to Greenville Loop. A directional drill will be required under a tributary to Hewlett's Creek prior to the intersection with Greenville Loop Road. The proposed route continues along Greenville Loop Road to the intersection with Pine Grove Road. This completes Section 1A.

The preferred section 2 route (C) extends from Pine Grove Drive near COW PS 34 into a residential area within the right of way of Brightwood Road. The route then parallels Hewlett's Creek to the north to avoid the extremely wet conditions along Hewlett's Creek. From this point, the proposed alignment crosses College Road to Holly Tree Road behind Longleaf Mall. The planned alignment follows a proposed utility easement to Pine Valley Drive near Beauregard Drive, to avoid Shipyard Boulevard. From Pine Valley Drive, the alignment continues through a residential area along Jeb Stuart Drive and then turns along Early Drive across Stonewall Jackson to Pettigrew Drive. At Pettigrew Drive the route turns southwest along Pettigrew to the existing easement at Semmes Drive. This area is characterized by existing underground water, sewer, and communications facilities.

Section 3 extends follows the route of the existing force main along Independence Boulevard and River Road to the Southside WWTP. This alignment should be coordinated with the pending road improvement plans for Independence Boulevard.

9.2.1.3. Regulatory Considerations / Environmental Impacts

Given the lengths of the proposed force main and the associated routes as described above, several areas of regulatory compliance should be considered. Appropriate permitting and document submittals will be required for the following:

- *SEPA* – This project will likely require a formal Environmental Assessment (EA) be produced and submitted to the State Clearinghouse. Given the length and diameter of the force main coupled with the capacity of the proposed pumping station, thresholds making an EA necessary are met. Additionally, other federal permits will be required through the US Army Corps of Engineers. These facets of the project, along with expenditure of government funding will most likely require an EA submittal to the State.
- *NC Division of Water Quality Sewer Construction Permit* – This project would likely require the submission of plans and specifications to NC DWQ for review and approval of the pump station and force main system in lieu of the “fast-track” permit.
- *NC DENR – Land Quality* – this project will greatly exceed the one acre threshold for requiring the submission for a sedimentation and erosion control permit.
- *CAMA* – Given the proximity of this project are to the coast and the possibility of the project to cross and/or affect coastal waters, a CAMA minor permit will most likely be required. Depending on the limits and restrictions of impacts to some of the CAMA related areas, a CAMA major permit could be triggered.

- *Wetlands* – It is anticipated that this project will impact wetlands with the extent depending on the final selected route and pump station site. All wetland encroachments will require permitting through the US Army Corps of Engineers and NC DENR – DWQ.
- *US Army Corps of Engineers* – Depending upon the projected impacts to jurisdictional areas, it may be possible to permit this project under the current standard Nationwide permit. The Corps may require submittal of a more cumbersome and tailored Individual permit for this project.
- *Stormwater* – State and local stormwater regulations will apply to this project as well. It is not anticipated that the construction of the force main will add additional impervious surface to the project area. Therefore, stormwater measures will likely be limited temporary erosion control plan implementation. However, the proposed pumping station will likely add more impervious surface, thereby triggering a requirement for stormwater treatment.
- *Encroachments* – Any encroachments into City or NCDOT rights of way will require applying for and obtaining appropriate executed encroachment agreements. It is anticipated that this project will jack and bore most major NCDOT crossings such as Oleander and College Road in an effort to minimize disturbance to traffic.

9.2.1.4. Opinion of Probable Construction Costs

An opinion of probable project costs has been established for implementation of Alternative 3. The project costs include a 20% construction cost contingency. Technical services are estimated at 15% of the construction cost. Construction costs are based on recent similar construction supplemented with vendor supplied equipment and material budget estimates. All costs are presented in 2006 dollars. We recommend a project budget of \$19.3 million for this alternative.

9.2.2. Alternative No. 4

9.2.2.1. Description

This alternative is similar to alternative 3 except that it includes provisions necessary to handle flows from Major Basin II in addition to Major Basins III, IV, and V. Improvements include flow expansion, operational improvements, and criticality improvements to COW PS 35; installation of a new re-pump station and force main; installation of a new force main from COW PS 35 to the Southside WWTP with periodic interconnections with the existing NEI force mains; and operational and criticality improvements to COW PS 34.

Since the wetwell capacity of COW PS 35 will be exceeded in this alternative, additional wetwell capacity is required. There is no room on the existing site for an expanded wetwell so a new pump station will be necessary. Some consideration was given to upgrading NHC PS 77; however, the pump station sits on a very tight site, and it will not accommodate the changes necessary. Some consideration was also given to expanding the COW PS 35 site to add wetwell capacity. Since the only developable adjacent site is

occupied by an office building we did not think it was prudent to count on being able to obtain this site in projecting necessary budget needs; however, if this site can be purchased there will be several operational advantages and construction cost efficiencies to be gained by the NEI team.

To make best use of the existing equipment at NHC PS 77 and to assist with coordinated operation with COW PS 35, the pump station should be located as near to COW PS 35 as possible. The new pump station should include screening, variable speed pumping, corrosion control, and odor control facilities.

Implementation of this alternative will include the major components tabulated below.

- | | |
|-----------------|---|
| COW PS 35: | <ul style="list-style-type: none">- Replace Pump #3 and Pump #4 with 4,200 gpm pumps and drives and install a 24-inch pump station header with flow meter. Electrical capacity improvements will include replacing the service entrance, stand-by generator, and automatic transfer switch.- Replace the County junction vault due to severe corrosion.- Implement SCADA Improvements- Proceed with bench testing and implement changes to OCCP |
| New PS: | <ul style="list-style-type: none">- Secure a site for the re-pump station.- Construct pump station with screening, corrosion control, and odor control systems.- Coordinate pump controls and SCADA system with COW 35 SCADA system. |
| COW PS 34: | <ul style="list-style-type: none">- Replace the automatic transfer switch (ATS) with an ATS with manual by-pass for temporary operation in the event of ATS electronics failure.- Work with Progress Energy to clear trees from the power easement.- Implement SCADA Improvements- Proceed with bench testing and implement changes to OCCP |
| New Force Main: | <ul style="list-style-type: none">- Install approximately 49,000 LF of 30-inch force main. Pipeline corridor should be established in a manner to facilitate periodic pipeline interconnects. Force main interconnects between COW PS 34 and COW PS 35 should include flow control valves. |
| Ex. Force Main: | <ul style="list-style-type: none">- Raise top of ARV vaults above grade for maintenance access.- Replace all ARV's and connecting piping.- Install vent pipe on each ARV vault.- Replace ARV vault #4.- Repair ARV #11 vault collapsed wall.- Remove all trees from pipeline easements.- Replace COW PS 34 Junction Box (MH A)- Replace/Rehabilitate gravity section upstream of PS 34- Replace 2000 LF of 20" force main per thickness testing |

- Internally evaluate and rehabilitate existing following installation of parallel line
- Relocate approximately 7,000 LF of 20-inch force main along Hewlett's Creek to the new parallel force main route.

A construction sequence similar to that discussed in alternative 3 can be applied under this alternative as well; however, since the motor horsepower will likely exceed 200 hp, the VFDs being installed with the City's current PS 34 and PS 35 upgrade project to drive the largest two pumps will need to be replaced with larger units. Temporary pump drive will need to be installed on the larger pumps while the VFD's are being up-sized.

Since flow from Major Basin II is not diverted away from the NEI under this alternative, a capacity expansion of the Southside WWTP would need to begin very soon. As discussed in alternative 3 above, the costs to treat wastewater at the Southside WWTP following a plant expansion would likely increase significantly for all NEI partners.

9.2.2.2. Preliminary Routing Analysis

The routing analysis is the same for Alternatives 3 and 4.

9.2.2.3. Regulatory Considerations / Environmental Impacts

Because the routing analysis is the same for Alternatives 3 and 4, the regulatory considerations and environmental impacts are as well.

9.2.2.4. Opinion of Probable Construction Costs

An opinion of probably project costs has been established for implementation of Alternative 4. The project costs include a 20% construction cost contingency. Technical services are estimated at 15% of the construction cost. Construction costs are based on recent similar construction supplemented with vendor supplied equipment and material budget estimates. All costs are presented in 2006 dollars. We recommend a project budget of \$26.6 million for this alternative.

9.2.3. Relocation of the 24-inch Force Main Paralleling Hewlett's Creek

In an effort to further improve the reliability of the NEI system, it recommended that the section of the existing 24" force main paralleling Hewlett's Creek be relocated out of the wet area of the creek. This is recommended for the following reason:

- The area is difficult to access given the swampy conditions. This situation makes the line difficult and costly to inspect, maintain, and repair in the event of a spill. The inaccessibility will lengthen then time for identification and repair of a failure, increasing the volume of a spill.
- The existing gravity sewer is immediately adjacent to the existing force main. There have reported instances of damage to the force main during past construction of the gravity system. One of these repairs failed near Warlick

Drive, resulting in a spill. If other repairs were made with similar materials, the risk of future failures exists.

- The area is characterized by corrosive soils. The force main was originally installed with a polyethylene liner to protect the pipe. Given the proximity of past construction to the NEI, damage to the liner is likely. Without the protective liner, there is the potential for corrosion and failure.
- Leaks in this area are hard to identify and locate given the wet conditions. Also, any leaks not immediately repaired would directly influence surface waters given the proximity to the creek.

Given the above implications of these issues, relocation is recommended to improve the overall reliability of the NEI System. A viable alternative route is to install this section of force main in conjunction with the proposed parallel force.

9.2.4. Discussion of Alternatives

The following discussion weighs the pros and cons of these alternatives against key criteria for the fundamental objectives to increase reliability and improve the event management capabilities of the NEI:

Improved Reliability: Implementation of alternate 3 would divert about 3.6 MGD of peak flow (1.4 MGD average daily flow) away from the NEI to the Ogden Interceptor. Gravity systems are generally more reliable and have a longer life span than mechanical systems so alternative 3 would create a more reliable NEI system.

Improved Event Management: Under alternative 3 there is less flow through the NEI system. As such there is less flow to manage in the event of a mechanical or pipeline failure making alternative 3 more favorable from an event management perspective.

Capital Cost: Capital costs have been prepared showing that alternative 4 is more expensive to execute; however, these costs do not include improvements that may be necessary to improve the capacity of the Ogden Interceptor system. Once the County completes its interceptor evaluations these capital costs should be figured into the costs presented herein.

Operating Costs: There are two primary components of the operating costs affected by these two alternatives: pumping costs and treatment costs. Since the gravity interceptor would do a majority of the work under alternative 3, pumping costs would be much less under that alternative. Currently it costs more to treat wastewater at the Northside WWTP due to its low discharge limits. However, if alternative 4 is implemented an expansion of the Southside WWTP would be necessary in the near future making the difference in treatment costs between the two plants less significant. As such, alternative 3 would create less operating

costs because it requires less pumping energy and extends the life of the Southside WWTP at its current capacity.

Two primary goals of the NEI evaluation are to improve reliability of the NEI and to improve event management capabilities. Other important factors include capital costs and operational costs. In considering the two alternatives, alternative 3 best meets at least three of these four goals. How the alternatives compare on a capital cost basis cannot be determined at this time. The County is currently working on an analysis to evaluate the capacity of the Ogden Interceptor. If the capacity is inadequate, capital cost projections should be developed to remedy the capacity situation and those costs should be added to the costs of alternative 3 for comparison.

With comparable capital costs in place the NEI team should weigh the improved reliability, improved event management, and lower operating cost advantages of alternate 3 with the capital costs differences between alternative 3 and alternative 4.

10 Conclusions and Recommendations

We recommend implementation of the Capital Improvements Plan and operational modifications which are detailed in the Technical Memorandums and summarized in the Preliminary Engineering Report. To implement these recommendations, we project capital budget of \$26.3 to \$33.9 million over the next four years, depending on whether Major Basin II is included or excluded in the NEI service area. The following is a summary task list of the major steps for implementation of the recommended improvements. Items 1 through 5 should commence as soon as possible and completed simultaneously. The remaining items should be completed in sequential order:

1. Proceed with bid and construction of the recommended Deficiency Identification and Repair Program improvements.
2. Perform the bench scale odor and corrosion control evaluation of the selected chemicals.
3. Implement the recommendations of the Operational Evaluation and Criticality Assessment.
4. Proceed with design of the NEI expansion by initiating the routing analysis, survey, preliminary design, and environmental assessment of the proposed parallel force main from Pump Station 35 to the Southside Wastewater Treatment Plant.
5. Resolve the future direction of wastewater flow from Major Basin II to determine if this flow will be tributary to the NEI and accounted for in the design.
6. Proceed with design of the Pump Station 35 expansion and the re-pump station (if Alternative No. 4 is selected), and final design of the force main.
7. Construct the NEI expansion.
8. Proceed with design of the future force main rehabilitation. This should be scheduled so that design is completed as the NEI expansion is completed so that construction can proceed as soon as possible.
9. Construct the NEI rehabilitation.

11 Capital Improvements Program

11.1 General

Recommendations of the preceding sections are consolidated to three CIP line items, the Deficiency Identification and Repair Program, the NEI Expansion Program, and the NEI Rehabilitation Program. Table 11.1 shows a summary of the proposed NEI Capital Improvements Plan FY 2006-2010, while Table 11.2 shows a cost breakdown for engineering and construction costs for the Capital Improvements Plan. Detailed project estimates are also included in Tables 11.3 through 11.6.

11.2 Deficiency Identification and Repair Program

Based on the field investigations and thickness testing, areas requiring immediate replacement or rehabilitation were identified for contractor solicitation. These items were identified as five separate project areas as listed below:

- *ARV retrofits* – This portion of the DIRP entails the replacement of ARV assemblies and improvements to existing vaults for maintenance and accessibility in accordance with TM #4.
- *Greenville Loop Force Main Replacement* – This DIRP project will involve the replacement of approximately 2,000 LF of deteriorated force main identified during thickness testing.
- *Gravity Sewer Rehabilitation/Replacement* – This DIRP project consists of the lining of the gravity discharge section of the NEI directly upstream of COW PS 34. Additionally, the project accounts for the replacement of existing 20" gravity sewer along Pine Grove with 24" new gravity sewer.
- *COW PS 34 Junction Box Upgrade* – In an effort to reduce turbulence, minimize odors, and replace damaged structures, the combining manhole structure will be replaced and reconfigured to better accept and combine flows immediately upstream of COW PS 34.
- *COW PS 35 Junction Box Upgrade* – In an effort to reduce turbulence, minimize odors, and replace damaged structures, the combining NHC junction box structure will be replaced and reconfigured to better accept and combine flows immediately upstream of COW PS 35.

11.3 NEI Expansion

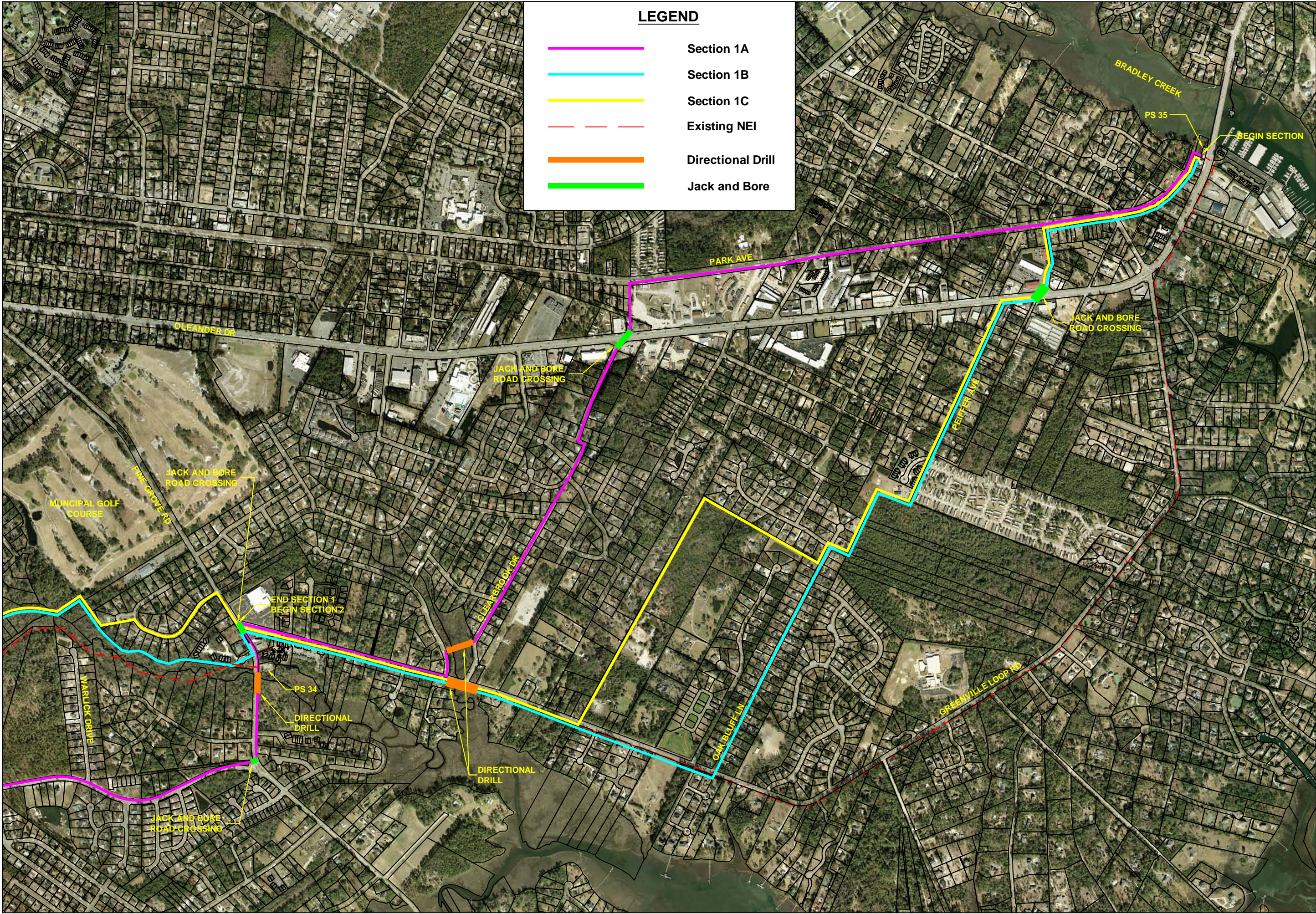
In an effort to position the NEI system to accommodate future flow increases and allow for system redundancy and generally improve the reliability of the system, several future projects will be required.

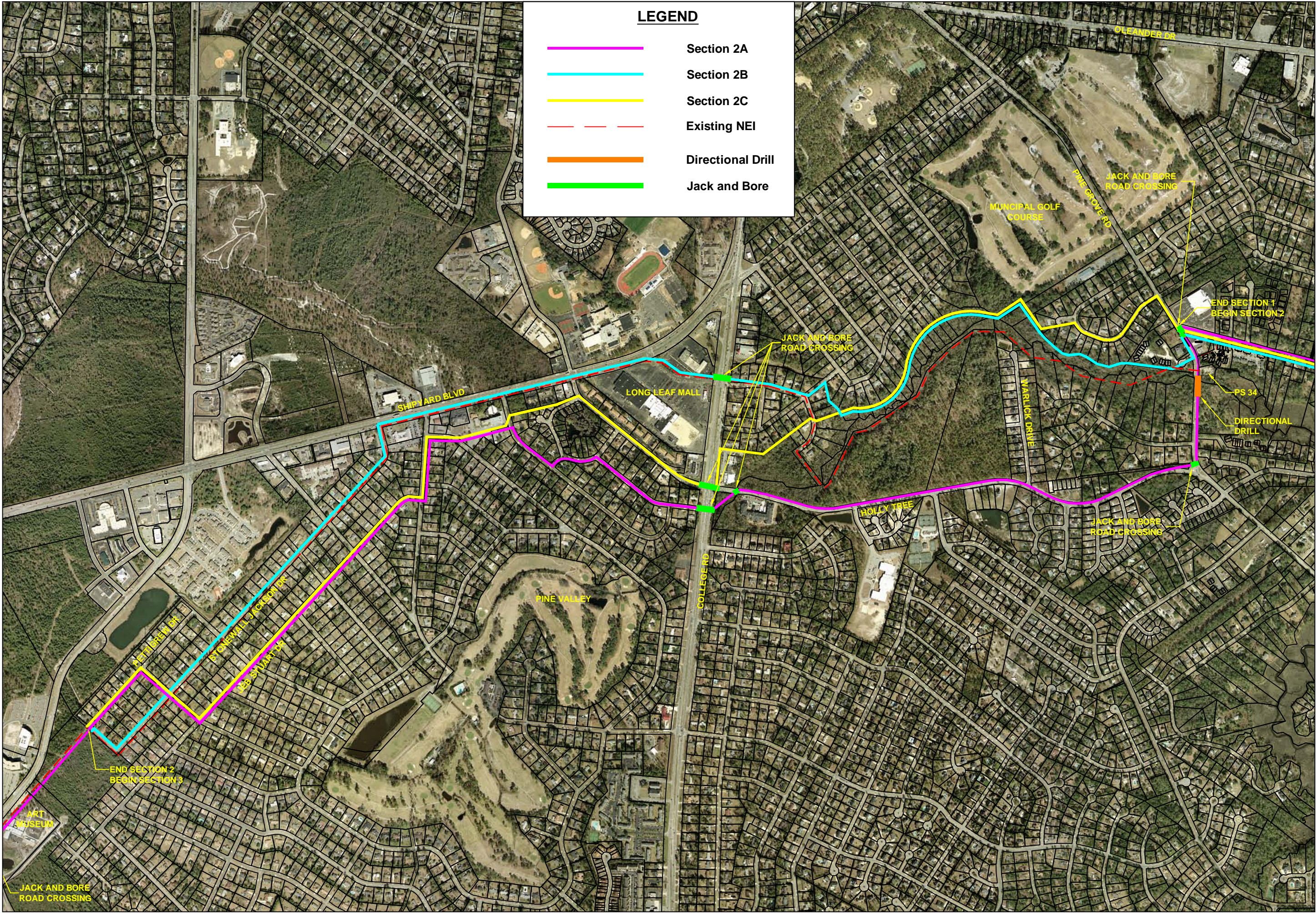
- *OCCP Modifications* – As a means to better manage odor and corrosion control chemical addition changes and feed system modifications will be required.

- *Parallel Force Main and Interconnections* – A parallel force main will be constructed to allow for flow increases and incident management by way of crossover interconnections. The size of the force main will range from 24-inch to 30-inch pending Major Basin II flow diversion decisions.
- *Pumping Station Upgrades* – Pumping station upgrades to COW PS 34 and COW PS 35 will be necessary to ensure reliability of the NEI system. A capacity expansion COW PS 25 will be required. Pending Major Basin II flow diversion decisions, construction of a new PS may be necessary.

11.4 NEI Rehabilitation

- *ARV Vault Replacements* – As recommended in TM #4, the ARV vaults not replaced as part of the DIRP process will require removal and replacement with the proposed ARV detail to facilitate better maintenance access and inspection.
- *20" and 24" Force Main Rehabilitation* – In accordance with TM #4, the exact extents of the force main categorized as needs replacement or rehabilitation will need to be verified. Following verification of limits of corrosion, trenchless rehabilitation (lining) or replacement of these force mains is recommended.
- *Relocation of the 24-inch force main section paralleling Hewlett's Creek* - In an effort to further improve the reliability of the NEI system, it recommended that the section of the existing 24" force main paralleling Hewlett's Creek be relocated out of the wet area of the creek. influence surface waters given the proximity to the creek.





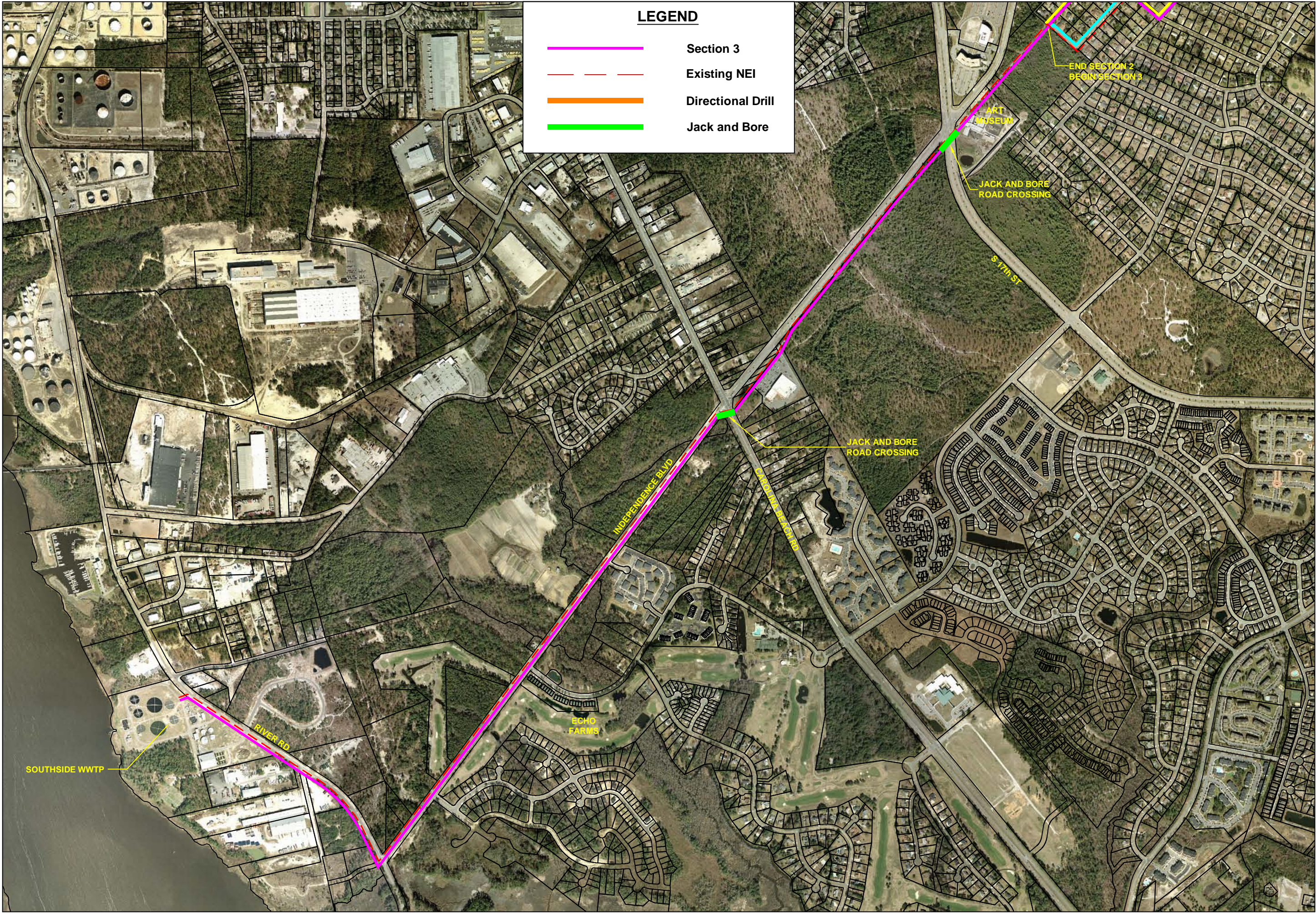


TABLE 11.1 - PROPOSED NORTHEAST INTERCEPTOR CAPITAL IMPROVEMENTS PLAN FY 2006-2010

CIP with Alternative #3

		2006-07	2007-08	2008-09	2009-10	Total
1	Deficiency Identification and Repair Program	\$1,860,000	\$0	\$0	\$0	\$1,860,000
2	Northeast Interceptor Expansion*	\$1,510,000	\$5,950,000	\$11,830,000	\$0	\$19,290,000
3	Northeast Interceptor Rehabilitation	\$0	\$0	\$340,000	\$3,560,000	\$3,900,000
	Total Northeast Interceptor Project Costs (2006 \$)	\$3,370,000	\$5,950,000	\$12,170,000	\$3,560,000	\$25,050,000
	Total Northeast Interceptor Project Costs (Current Year \$ @ 3% Inflation)	\$3,370,000	\$6,130,000	\$12,910,000	\$3,890,000	\$26,300,000

* - Alternative 3 - Excludes flow from Major Basin II

CIP with Alternative #4

		2006-07	2007-08	2008-09	2009-10	Total
1	Deficiency Identification and Repair Program	\$1,860,000	\$0	\$0	\$0	\$1,860,000
2	Northeast Interceptor Expansion**	\$2,080,000	\$8,200,000	\$16,280,000	\$0	\$26,560,000
3	Northeast Interceptor Rehabilitation	\$0	\$0	\$340,000	\$3,560,000	\$3,900,000
	Total Northeast Interceptor Project Costs (2006 \$)	\$3,940,000	\$8,200,000	\$16,620,000	\$3,560,000	\$32,320,000
	Total Northeast Interceptor Project Costs (Current Year \$ @ 3% Inflation)	\$3,940,000	\$8,450,000	\$17,630,000	\$3,890,000	\$33,910,000

** - Alternative 4 - Includes flow from Major Basin II

TABLE 11.2 - PROPOSED NORTHEAST INTERCEPTOR CAPITAL IMPROVEMENTS PLAN COST BREAKDOWN

CIP with Alternative #3																						
	Project Title	2006-2007				2007-2008				2008-2009				2009-2010				Total				
		Engineer Fee	Const. Costs	Other Costs	Project Cost	Engineer Fee	Const. Costs	Other Costs	Project Cost	Engineer Fee	Const. Costs	Other Costs	Project Cost	Engineer Fee	Const. Costs	Other Costs	Project Cost	Engineer Fee	Const. Costs	Other Costs	Project Cost	
1	Deficiency Identification and Repair Program	\$240,000	\$1,620,000		\$1,860,000													\$240,000	\$1,620,000		\$1,860,000	
2	Northeast Interceptor Expansion*	\$1,510,000			\$1,510,000	\$250,000	\$5,700,000		\$5,950,000	\$760,000	\$11,070,000		\$11,830,000					\$2,520,000	\$16,770,000		\$19,290,000	
3	Northeast Interceptor Rehabilitation									\$340,000			\$340,000	\$170,000	\$3,390,000		\$3,560,000	\$510,000	\$3,390,000		\$3,900,000	
	Total Northeast Interceptor Improvements (2006 \$)	\$1,750,000	\$1,620,000	\$0	\$3,370,000	\$250,000	\$5,700,000	\$0	\$5,950,000	\$1,100,000	\$11,070,000	\$0	\$12,170,000	\$170,000	\$3,390,000	\$0	\$3,560,000	\$3,270,000	\$21,780,000	\$0	\$25,050,000	
	Total Northeast Interceptor Improvements (Current Year \$ @ 3% Inflation)	\$1,750,000	\$1,620,000	\$0	\$3,370,000	\$260,000	\$5,870,000	\$0	\$6,130,000	\$1,170,000	\$11,740,000	\$0	\$12,910,000	\$190,000	\$3,700,000	\$0	\$3,890,000	\$3,370,000	\$22,930,000	\$0	\$26,300,000	

* - Alternative 3 - Excludes flow from Major Basin II

CIP with Alternative #4																					
	Project Title	2006-2007				2007-2008				2008-2009				2009-2010				Total			
		Engineer Fee	Const. Costs	Other Costs	Project Cost	Engineer Fee	Const. Costs	Other Costs	Project Cost	Engineer Fee	Const. Costs	Other Costs	Project Cost	Engineer Fee	Const. Costs	Other Costs	Project Cost	Engineer Fee	Const. Costs	Other Costs	Project Cost
1	Deficiency Identification and Repair Program	\$240,000	\$1,620,000		\$1,860,000													\$240,000	\$1,620,000		\$1,860,000
2	Northeast Interceptor Expansion**	\$2,080,000			\$2,080,000	\$350,000	\$7,850,000		\$8,200,000	\$1,040,000	\$15,240,000		\$16,280,000					\$3,470,000	\$23,090,000		\$26,560,000
3	Northeast Interceptor Rehabilitation									\$340,000			\$340,000	\$170,000	\$3,390,000		\$3,560,000	\$510,000	\$3,390,000		\$3,900,000
	Total Northeast Interceptor Improvements (2006 \$)	\$2,320,000	\$1,620,000	\$0	\$3,940,000	\$350,000	\$7,850,000	\$0	\$8,200,000	\$1,380,000	\$15,240,000	\$0	\$16,620,000	\$170,000	\$3,390,000	\$0	\$3,560,000	\$4,220,000	\$28,100,000	\$0	\$32,320,000
	Total Northeast Interceptor Improvements (Current Year \$ @ 3% Inflation)	\$2,320,000	\$1,620,000	\$0	\$3,940,000	\$360,000	\$8,090,000	\$0	\$8,450,000	\$1,460,000	\$16,170,000	\$0	\$17,630,000	\$190,000	\$3,700,000	\$0	\$3,890,000	\$4,330,000	\$29,580,000	\$0	\$33,910,000

TABLE 11.3 - PROPOSED DEFICIENCY IDENTIFICATION AND REPAIR PROGRAM

The Deficiency Identification and Repair Program consists of five separate projects:

1.1) ARV retrofits, where TM#4 calls for replacement of ARV assemblies and improvements.

1.2) Greenville Loop Force Main Replacement, where approximately 2,000 lf of deteriorated force main will be replaced.

1.3) Gravity Sewer Rehabilitation/Replacement, where 350 lf of 20" gravity sewer will be rehabilitated, 30 lf of 20" gravity sewer at Greenville Loop Road and Tidal Oaks will be replaced with 20" gravity sewer, 110 lf of the existing 20" gravity sewer along Pine Grove will be replaced with 24" gravity sewer, three - 5' diameter manholes, one - 6' diameter manhole and one Vortex manhole insert will be added to aid in reducing turbulence, minimize odors, and replace damaged structures.

1.4) PS 34 Junction Box Upgrade, where 30 lf of 10" force main, 26 lf of 12" gravity sewer, 22 lf of 18" gravity sewer, 95 lf of 24" gravity sewer, two 6' diameter manholes, one - 10' diameter manhole, and two Vortex manhole inserts will be added to aid in reducing turbulence, minimize odors, and replace damaged structures.

1.5) PS 35 Junction Box Upgrade, where 30 lf of 10" force main, 30 lf of 16" force main, 40 lf of 8" gravity sewer, 35 lf of 24" gravity sewer, one - 4' diameter manhole, one - 5' diameter manhole, and one - 10' diameter manhole will be added to replace and reconfigure of the junction immediately upstream of PS 35 to better accept and combine flows.

	Project Title			
		Engineer Fee	Const. Costs	Project Cost
1.1	PS 35 Junction Manhole Construction	\$24,100	\$159,900	\$184,000
1.2	PS 34 Manhole A Area Construction	\$35,900	\$239,100	\$275,000
1.3	Greenville Loop Force Main Replacement	\$117,300	\$781,700	\$899,000
1.4	Gravity Replacement behind Scotchman's	\$38,200	\$253,800	\$292,000
1.5	DIRP ARV Construction	\$27,800	\$185,200	\$213,000
1	Deficiency Identification and Repair Program	\$240,000	\$1,620,000	\$1,860,000

TABLE 11.4 - PROPOSED NEI EXPANSION PROGRAM WITH ALTERNATIVE #3

The NEI Expansion with Alternative #3 consists of three future projects:

2.1) OCCP Modifications, where nine universal chemical feed systems will be added throughout the NEI system to help better manage odor and corrosion control chemical additions and feed system modifications.

2.2) Parallel Force Main and Interconnections, where approximately 47,500 lf of 24" force main and several interconnections between the existing 20" and 24" force mains and the new 24" force main will be added to allow for flow increases and incident management by way of crossover interconnections.

2.3) Pumping Station Upgrades, where pumping station upgrades of PS 34 and PS 35 will be necessary to ensure reliability of the NEI system. Pending diversion decisions, expanding PS 35 or construction of a new PS will be necessary.

	Project Title				
		Engineer Fee	Const. Costs	Other Costs	Project Cost
2.1	OCCP Modifications	\$68,400	\$455,600		\$524,000
2.2	NEI Parallel Force Main (24" Assumed - Alt. 3)*	\$2,078,700	\$13,857,300		\$15,936,000
2.3	NEI Alt 3 PS Improvements	\$369,000	\$2,458,000		\$2,827,000
2	NEI Expansion	\$2,520,000	\$16,770,000	\$0	\$19,290,000

* - Alternative 3 - Excludes flow from Major Basin II

TABLE 11.5 - PROPOSED NEI EXPANSION PROGRAM WITH ALTERNATIVE #4

The NEI Expansion with Alternative #4 consists of three future projects:

2.1) OCCP Modifications, where nine universal chemical feed systems will be added throughout the NEI system to help better manage odor and corrosion control chemical additions and feed system modifications.

2.2) Parallel Force Main and Interconnections, where approximately 47,500 lf of 30" force main and several interconnections between the existing 20" and 24" force mains and the new 30" force main will be added to allow for flow increases and incident management by way of crossover interconnections.

2.3) Pumping Station Upgrades, where pumping station upgrades of PS 34 and PS 35 will be necessary to ensure reliability of the NEI system. Pending diversion decisions, expanding PS 35 or construction of a new PS will be necessary.

	Project Title				
		Engineer Fee	Const. Costs	Other Costs	Project Cost
2.1	OCCP Modifications	\$68,400	\$455,600		\$524,000
2.2	NEI Parallel Force Main (30" Assumed - Alt. 4)**	\$2,484,300	\$16,560,700		\$19,045,000
2.3	NEI Alt 4 PS Construction and Improvements	\$912,000	\$6,077,000		\$6,989,000
2	NEI Expansion	\$3,460,000	\$23,090,000	\$0	\$26,560,000

** - Alternative 4 - Includes flow from Major Basin II

TABLE 11.6 - PROPOSED NEI REHABILITATION PROGRAM

The NEI Rehabilitation consists of two future projects:

3.1) ARV Vault Replacements, where additional vaults described in TM#4 will be removed and upgraded to facilitate better maintenance access and inspection.

3.2) 20" and 24" Force Main Rehabilitation, where in accordance with TM#4 and potential additional thickness evaluations, trenchless rehabilitation (lining) of the force mains will take place for the limits described in TM#4. Replace the Hewlett's Creek 24" force main of 7000 lf and relocate.

	Project Title				
		Engineer Fee	Const. Costs	Other Costs	Project Cost
3.1	Rehabilitation/Replacement of 20" and 24" Force Mains	\$470,000	\$3,133,000		\$3,603,000
3.2	ARV Vault Replacements	\$38,900	\$259,100		\$298,000
3	Northeast Interceptor Rehabilitation	\$510,000	\$3,390,000	\$0	\$3,900,000